R·E

# PAPERS

ON SUBJECTS CONNECTED WITH

# THE DUTIES

OF THE

# CORPS OF ROYAL ENGINEERS.

---

CONTRIBUTED BY MEMBERS OF THE ROYAL AND EAST INDIA COMPANY'S ENGINEERS,

AND

EDITED BY A COMMITTEE OF ROYAL ENGINEERS.

---

VOL. III.—NEW SERIES.

LONDON:
JOHN WEALE, 59, HIGH HOLBORN.
1853.

LONDON:
BRADBURY AND EVANS, PRINTERS, WHITEFRIARS.

# NOTICE.

The bulk of this volume, and the numerous plates, will explain the cause of the delay in publishing it. The Editors have likewise to apologise to several contributors that their papers have not been inserted for want of space and time.

G. G. LEWIS,
Major-General.

J. WILLIAMS,
Capt. Royal Engineers.

R. M. A. Woolwich,
*April* 2, 1853.

# CONTENTS.


| Paper | | Page |
|---|---|---|
| | Memoir of the late Major-General Colby, Royal Engineers, LL.D., F.R.S.L. & E., M.R.I.A., F.G.S., &c. &c. With a Sketch of the Origin and Progress of the British Trigonometrical Survey. By Lieutenant-Colonel Portlock, R.E., F.R. & G.S., F.R.A.S. & M.R.I.A., &c. | i—lxiv |
| I. | Report on the Disputed Boundary between Canada and New Brunswick. By Major Robinson, R.E. | 1 |
| II. | Remarks on the Military Operations in New Zealand. By Captain Collinson, R.E. | 5 |
| III. | Description of the Steam Basin, Docks, and Factory, and other Works recently executed in Portsmouth Dockyard. By Captain H. James, R.E., F.R.S., M.R.I.A., F.G.S., &c. | 77 |
| IV. | On the Relative Value of Specimens of Native Gold from the different Countries whence it is brought to Market in these Colonies. Communicated to the Royal Society of Van Diemen's Land. By His Excellency Sir W. T. Denison, R.E., F.R.S. | 103 |
| V. | Memoir and Estimate for a Breakwater formed of Diamond-shaped Piers of Masonry at intervals. By Lieutenant-Colonel Cole, R.E. | 119 |
| VI. | General Napier's Reply to Colonel Waddington | 126 |
| VII. | Siege Operations, Ancient. By Lieutenant Yule, Bengal Engineers | 128 |
| VIII. | Memoranda on the Use of Asphalte. Communicated by Colonel Oldfield, R.E. | 132 |
| IX. | Description of a Sixty Tons Hopper Barge, used at the Harbour Works, Alderney. From Drawings, &c., by James May, Esq., C.E., Harbour Works, Alderney. Communicated by Capt. Hassard, R.E. | 149 |
| X. | Observations on Groins, during Five Years at Eastbourne on the Sussex Coast, and Five Years at Hythe in Kent. By Lieutenant-Colonel Gordon, R.E. | 152 |

| Paper | | Page |
|---|---|---|
| XI. | Revetments or Retaining Walls. By Lieutenant-General Sir John Burgoyne, Inspector General of Fortifications . . . . | 154 |
| XII. | Some Account of the Field Works thrown up for the Defence of Sicily in 1810, with a Plan by Major-General Lewis, R.E. . . | 160 |
| XIII. | Memoir on the Polygonal Fortification constructed in Germany since 1815. By A. Mangin, Capitaine du Génie. Translated by Captain J. Williams, R.E. With Notes . . . . . . . . | 167 |
| XIV. | Bermuda.—Remarks Explanatory of the Gale that occurred in the Atlantic between the 22nd of September and the 3rd of October, 1852, to accompany the Meteorological Record for the month of September at Bermuda. By Lieutenant-Colonel Alexander, R.E. | 196 |
| XV. | Meteorological Observations. By Captain H. James, R.E. . . | 202 |


## ERRATUM.

In page lii, line 24, of Memoir of Major-General Colby, *for* '4th of November' *read* '24th.'

## ERRATA TO SECOND VOLUME.

Page 126, line 4, 5, *for* 'field battalions' *read* 'field batteries.'

,, 128, ,, 14, *for* 'New Croydon' *read* 'near Croydon.'

# LIST OF PLATES.


| No. of Paper. | Subject of the Paper. | No. of Plates. |
|---|---|---|
| II. | Military Operations in New Zealand . . . . . 2 Maps and | 2 |
| III. | New Works at Portsmouth . . . . . . . . . . . | 33 |
| V. | Proposed Breakwater, Table Bay . . . . . . . . . | 3 |
| VII. | Siege Operations, Ancient . . . . . . . . . . . | 3 |
| VIII. | Memoranda on the Use of Asphalte . . . . . . . . | 3 |
| IX. | Hopper Barge used at Harbour Works, Alderney . . . . . | 1 |
| X. | Proposed Groin, Hythe . . . . . . . . . . | 1 |
| XI. | Revetments or Retaining Walls . . . . . . . . . | 1 |
| XII. | Field Works for the Defence of Sicily (2 views of Messina, &c., in text, Paper XII.) . . . . . . . . . . | 1 |
| XIII. | Polygonal Fortification in Germany . . . . . . . . | 1 |
| XIV. | Bermuda.—Remarks explanatory of the Gale that occurred in the Atlantic between the 22nd of September and the 3rd of October, 1852 . . . . . . . . . . . . | 1 |

4

# Memoir of the late Major-General Colby, Royal Engineers, LL.D., F.R.S.L. & E., M.R.I.A., F.G.S., &c. &c. With a Sketch of the Origin and Progress of the British Trigonometrical Survey.

By Lieutenant-Colonel Portlock, R.E., F.R. & G.S., F.R.A.S. & M.R.I.A., &c.

When we turn from the contemplation of great actions, either in civil or military history, to an investigation of the causes which have led to their performance, we are too often doomed to experience the disappointment of finding the motive springs of brilliant acts, in themselves, mean and sordid. Were it, however, the object of this memoir to describe the moral rather than the intellectual man, the character of General Colby might be subjected without danger to the ordeal of such an inquiry, as few men were so free from the impulses either of avarice or of ambition. Affecting no contempt for the pecuniary remuneration of his services, and rightly considering the labourer worthy of his hire, he was always willing to apply what he derived from the service to its advancement; and hence it was that neither he nor any of his officers or assistants ever thought of calculating personal expense when it became necessary to push forward the work confided to their care. If, therefore, General Colby considered that officers of the Survey should be well paid, he was influenced, not by a spirit of accumulation, but by a desire to afford them the means of moving and acting with energy and effect under all circumstances. In like manner, though, in his early life, he was not indifferent to honorary rewards or distinctions, especially those of a scientific character, it cannot be said that at any time the desire of obtaining them exercised a powerful influence on his mind; and when, in later years, his affections became domestic in their tone, and were centered in his home and linked to his wife and children, he appeared absolutely to despise them.

A contempt for worldly honours, and an indifference to wealth, are often cited as characteristics of a great mind; and yet qualities so undoubtedly noble are on the whole more suited to the quiet philosopher than to the active man of business. A sense of duty will impel a man to do and to suffer much, and the love of a particular pursuit will render him regardless of difficulties, and blind to danger, just as the botanist will seek the rare plant, or the entomologist the wished-for insect, in the deadly marsh, the impervious forest, or in the burning desert; but when so much has been done and suffered, he who was unmoved by the apprehension of corporeal pain and danger will shrink from the mental torture of other men's criticisms, unless urged forward to the publication of his labours by the hope of attaining either wealth or honours for the present, or an undying fame for the future. The want of this stimulating and supporting principle induced in General Colby an indisposition to publish the details of the Survey, and a morbid apprehension of criticism; for, though no one was more prompt and energetic in action, no one more assiduous and skilful in observing, no one more confident in his own personal resources, he yet, after the death of General Mudge, gave the public no account of the Survey, and allowed the published maps to continue the only records of its progress and excellence. It is impossible not to regret this fatal error, as it has materially tended to alienate the Ordnance Survey from the good feelings of the scientific public, and has thrown over a work, with which not merely every scientific, but also every practical man, should be familiar, an air of official mystery and seclusion. If, however, General Colby neglected the means of ensuring his own personal fame, he was nobly disinterested in respect to the services, merits, and rewards of those acting under him; and whoever has studied human nature, and observed how many a man of great talents has laboured all his life in the shade, whilst a superior in rank has been lifted up, as it were, upon his shoulders, to eminence, will appreciate the high-minded manner in which General Colby bore testimony to the merits of his officers, and permitted them on several occasions to publish portions of the work rather as principals in it, than as assistants: a generous line of conduct to which must be ascribed the first successful steps in public life of Drummond, Larcom, Dawson, and others; the first opportunities of exhibiting those talents which have subsequently placed them in important public stations.

Some portion, indeed, of the delay in publication which it has been necessary to notice, was the result of the early distinction which several of General Colby's officers thus acquired, the preparation of part of the work for publication having been relinquished by Captain Drummond on his appointment to an important political office; and, subsequently, by Lieutenant Murphy, on his becoming an associate in the scientific and arduous Euphrates expedition of Colonel Chesney. In respect to temper, General Lewis and his other contemporaries have spoken favourably of General Colby, who had the great merit of having conquered himself, and reduced a naturally warm disposition to such discipline and order, that few could say they had ever seen him lose his self-command: and if he ever did so, his usual equanimity was disturbed but for a moment, as may be judged from the following characteristic anecdote: "The writer of this memoir had prepared the great instrument for observation on Slieve Donard early in a morning of August, 1826, and had watched for some time the light as it slowly broke behind the dark mountains of Cumberland, when observing the outline of Sea Fell gradually assuming a distinct shape, he called up Colonel Colby who instantly came to the Observatory and directed the telescope on the mountains. The distance was 111 miles, and the difficulty, therefore of accurately bisecting the object very great. Alternately, however, Colonel Colby and the present writer attempted to achieve the task, and at length Colonel Colby was on the point of successfully finishing his observation, which would have been a geodesical triumph, as including the longest side of a triangle ever attempted, when an officer on entering the Observatory accidentally struck his elbow, and threw the telescope off the object. A momentary ejaculation of anger escaped his lips, but though he could not again succeed, and the object was therefore lost, he never afterwards alluded to the subject." In manners and habits, he was singularly simple and temperate, being as much at home and as satisfied on the mountain top with the most ordinary fare, as in comfortable winter quarters with corresponding good cheer. In London, when a bachelor, he dined very often at the clubs of scientific and literary societies, being a member of almost every one then established; but all who served under him at that time will remember to have, on some occasion, met him running rather than walking (for such was his custom) along the street on his return from the Ordnance-office to the Tower, and to have been greeted by the hearty invitation, "Come back, my boy, and take a beef-steak with me" (which steak often expanded into excellent fish and a good fat turkey), or "Come to the lecture at the London Institution, and let us take a chop by the way;" simple festivities, unostentatious hospitalities, which will never be banished from the recollection of those who shared them. When married, his hospitality was equally hearty and equally unostentatious; and those who were privileged to become occasionally inmates of his house, must warmly remember how completely at home and how happy they were made in that well-ordered and peaceful family.

In person General Colby was rather short, and possessed of a singularly nervous and elastic frame, which no fatigue could overcome. Exposed almost bare-breasted to the storm, he appeared unaffected by the bitter blasts of winter, and day after day he persevered in walks over mountain districts which no ordinary strength could have mastered. His personal deportment was not perhaps dignified, but there was about him an air of will and determination which secured for him the obedience and respect of his subordinates; and when called upon to submit to a painful inquiry into the state of the Irish Survey, he exhibited that higher dignity of the mind which is manifested by a calm self-possession and a maintenance of self-respect under very irritating circumstances; or in other words, by the possession and display of that steady firmness which makes a man superior to the world. To his character as a husband and father, his bereaved widow and children, who prized so highly his affection whilst living, and who now so bitterly deplore his loss, can alone bear fitting testimony, though many have witnessed with gratification the playful cheerfulness and the unruffled calm which pervaded his domestic establishment, and told, in language low but deep, that discord was there no welcome guest. His intercourse with men at large was more open to observation, and in it, as in the conduct of most erring mortals, there was much to admire and something to blame. His tastes led him to prefer the company and friendship of men of science; but in judging of their relative excellence he was sometimes led to under-estimate it by over-strained prejudice, or to over-estimate it by over-heated enthusiasm. His judgment, however, was often very sound in such matters, and at all times there was an honest independence in the expression of his opinions, so that he acquired and enjoyed through life the friendship of some of the most scientific men of the day. In respect to his officers, Major Dawson, who was for some time intimately associated with him in the Scotch Trigonometrical Survey, observes—"That in the winter months he was pleased to have his officers with him, and was always most hospitable and kind to them; and that the trigonometrical survey under him, though certainly a wild and most arduous service, was nevertheless, for a young man, a life pleasant enough." And the same witness has thus spoken of his conduct towards the men—"He would lend his own hand to the raising of stones and building objects for observation, or to make houses to shelter the soldiers in camp; he would occasionally join with the men in a game of quoits, or in putting the stone or crowbar, and was a warm promoter of their feast at the close of each trigonometrical season." It cannot be a matter of surprise that, under such a heart-warming system, privations and fatigues seemed as nothing; and it is only to be regretted that some of his officers should have had reason to complain that he subsequently appeared to listen more to the dictates of utilitarianism than to those of feeling, in parting, as they thought, too coldly and readily, from men who had so long and so well served him; but let us remember that he had then ceased to be the independent head of the survey. With ordinary men, and in common things, he was rather eccentric, like the well-known character in Goldsmith's "Citizen of the World," never openly giving alms to the common beggar, and generally muttering something about the effects of idleness, whilst in secret he was warmly and liberally charitable. Here, however, this imperfect sketch of *the man* must cease, as it would be vain to attempt to pourtray his person more fully than has been done, or to bring home to those who knew him not the elasticity of his step, the rapidity of his movements in the streets, the slight peculiarities of dress which he so long retained.

The grandfather of General Colby was Mr. Colby of Rhosy Gilwin, Newcastle Emylin, South Wales, a gentleman of considerable landed property. His father, Thomas Colby, was an only son, and an officer of Royal Marines. For many years he appears to have been attached to the Chatham Division of Marines, and at that station most, if not all, of his children were born, the births of four being recorded in the registry of St. Margaret's *next* Rochester; a curious circumstance, as his family had already been connected with that locality through Sir Thomas Colby, Knt., who in 1724 was one of the representatives in Parliament of the city of Rochester, and contributed 200*l.* towards the repair of the Poor-house of this very parish, St. Margaret's. After this time Captain Colby again went to sea, and was severely wounded at the glorious battle of the 1st of June (1794); when the "Queen," the ship to which he belonged, commanded by Sir Allen Gardner, assisted in breaking the enemy's array, and leading along the line and receiving successive broadsides, finally engaged the "Jemmapes" in a desperate conflict which, though successful, left her too crippled to be able to take possession of her vanquished opponent. Captain Colby then attained the rank of major in the army. The grand uncle of General Colby was Captain Colby of the Royal Navy, who lost an eye in the service; he was also a gentleman of considerable property, and his estate, including the beautiful demesne of Fynone, is now in possession of John Colby, his lineal descendant and nephew of General Colby, whose sister married her cousin Mr. Colby of Fynone. On the mother's side General Colby was descended from Captain Hadden, who served at the celebrated siege of Belleisle.

It will be remembered that in 1761, or some few years after the defeat of the French fleet by Admiral Hawke off this island, which lies at the north end of the Bay of Biscay, it was determined to make an attack on the island itself; and that in consequence the British fleet, commanded by Commodore Keppel, and having on board a considerable land force (8000 men), under General Hodgson, approached it on the 7th of April. The island of Belleisle originally belonged to the Comptes de Cornouailles, a small district of Bretagne, by whom it was bestowed on the Abbey of Quimperlé; but the monks, finding it very troublesome to preserve their property from depredation and pillage, whether in war by soldiers or in peace by pirates, petitioned Charles IX. to permit them to exchange it for other property with the Compte de Retz, then Governor of Bretagne; and on the completion of this exchange, the Count was raised (1573) to the dignity of Marquis of Belleisle. In 1718, during the reign of Louis XV., and regency of the Duke of Orleans, the island became by exchange the property of the Crown. It is a little to the north-west of the mouth of the Loire, nearly parallel to, and about seventeen miles distant from, the general shore line of Bretagne though the peninsula of Quiberon, approaches within seven miles of it. The length is about twelve miles, and greatest breadth six; and the island stretches from north-west to south-east: it is surrounded by rocks, and the side facing Bretagne is nearly inaccessible, the sea breaking with violence against its cliffs. About midway between Point Loemaria, on the south-east point, and the Conigues Roches, close to the south-west point of the island, stands Palais, the principal town on the north-east side, or looking towards Bretagne. This town is divided into two by a canal or inlet which receives the tidal stream, and is crossed by a bridge of communication: it is fortified; the most inhabited portion, which lies on one side of the canal, being principally covered by a horn-work, which is commanded by the citadel on the opposite side.

On the 8th of April the English attempted to land in a sandy bay, near Point Loemaria, but were repulsed with considerable loss, the enemy being in possession of a small fort near the landing-place, and having also entrenched themselves on a steep hill, the *base of which* they had *scarped* so as to render it somewhat like the newly proposed earth forts of Mr. Ferguson. For some time the weather prevented a renewal of the attack, but at length the whole English force was landed, and the enemy driven within the walls of the town; this successful attempt having been commenced by a small body of men under Brigadier-General Lambert, who scaled the rocks at a part where their apparent inaccessibility had rendered the defenders less vigilant, and at a moment when the attention of the enemy was occupied by a continued cannonading of the hill forts, and by two feints or false attacks. The garrison was subsequently driven from the town into the citadel, which, finally capitulating on honourable terms, the island remained in possession of the British until the peace of 1763, when it was restored to France. These particulars have been mentioned as a curious tradition, preserved in the Colby family, relates that Captain Hadden was accompanied, on this arduous occasion, by his son, a child of eight years of age, who with the agility of boyhood first climbed either the rock or the wall of the town, and thus, being followed by his father, pointed out to the soldiers the way to victory. This boy soldier was subsequently Colonel Hadden of the 11th regiment, and Paymaster of the Forces in Portugal. General Hadden of the Royal Artillery was another son of the captain: he first served in North America under General Burgoyne in 1778, and remained in that country until captured at York Town, in 1781. In 1793, when a captain, he became secretary to the Duke of Richmond, Master-General of the Ordnance, and was afterwards on the staff in Portugal as adjutant-general under Lieutenant-General Sir Charles Stuart. On returning to England he again became secretary to the Master-General and was finally appointed Surveyor-General of the Ordnance. On the 29th of October, 1817, he died, and in the "Morning Chronicle" of Nov. 5, of that year, a biographical notice of him concludes with a warm eulogium on his honourable character as a brave officer and a good man, ending thus: "Of him, as it was formerly of a virtuous patriot, it may be justly said, he lived honest and died poor."

Cordelia Hadden, the sister of these distinguished officers, was mother of General Colby, who appears to have been her eldest child. He was born on the 1st of September, 1784, at Rochester, and baptised at St. Margaret's on the 29th. His years of infancy were, like those of his brothers and sisters, doubtless passed either at Rochester or Chatham; but when his father again went to sea, he was confided to the care of his father's sisters, who lived at the family seat, Rhosy Gilwin, and by them brought up until sent to school at Northfleet in Kent under

Dr. Crockell, an able master. The General often pointed out the grey tower of Northfleet church, and spoke with much feeling of his connection with its school. From Northfleet he was transferred to the Royal Military Academy at Woolwich, and obtained his first commission as Second Lieutenant of Engineers on the 21st of December, 1801.

On the 12th of January, 1802, Captain Mudge, R.A., then superintendent of the survey, applied to the Earl of Chatham, requesting that Lieutenant Colby might be attached to that work, and his appointment took place the same day. Captain Mudge's letter, referring to Lieutenant Colby as a young gentleman who has just got his commission, proceeds thus—"I find him, *on examination*, well grounded in the rudiments of mathematics, and in other respects perfectly calculated to be employed in this business. I beg to point out to your lordship the expediency of Lieutenant Colby being attached to me with some degree of permanency, and to request you will assign him to my orders on that principle." It is certainly possible that the name of Lieutenant Colby may have been brought before General Mudge by his uncle, General Hadden, then Surveyor-General of the Ordnance, through the Master-General's secretary, General Neville, who was a very near relative of Captain Mudge, but there cannot be a doubt that the selection was made from the motive assigned in the above letter, and that it was wise and just, and never regretted by General Mudge, may be gathered from his subsequent letter of September 9th, 1813, in which he thus feelingly expresses himself—"This brings to my mind how happy I am to account myself, that Providence has placed to my hand so able and firm a friend as you are. You have served without fee and reward; but find the greatest satisfaction for your actions in not having served in vain."

Under the authority of the Duke of Richmond, Master-General of the Ordnance, a corps of draftsmen (or surveyors and draftsmen), had been formed, and, as will be shown hereafter, employed to complete the topographical part of the survey, by filling in the details required for a map. The establishment of this corps was a wise measure, and a necessary step towards the attainment of that harmony and perfection which ought to characterise a great national work. Mr. James Gardner, who was for many years chief draftsman, not only superintended the drawing and publication of the first maps, especially that of Kent, but also shared in the labours of much of the triangulation. To General Morse, then Chief Engineer, was due the very judicious idea of rendering this corps useful in instructing the young Engineer officers in sketching and surveying, and thus supplying one of the practical elements then wanting in the course of study. At his request, General Mudge allowed Mr. Stanley and Mr. Dawson, two of the most able surveyors and draftsmen of the corps, to undertake this task. In 1803, Mr. Dawson was engaged in the survey of Cornwall and stationed at Liskeard, having then under him his three first pupils, Lieutenants Williams, Boothby, and Boteler. Whilst there, Lieutenant Colby visited him on a tour of inspection, and when trying an old pair of pistols, and about to discharge one of them as he held the other by the barrel with his left hand, the latter exploded and burst, shattering his left hand, whilst one of the fragments made a fearful indent in his skull, the mark of which on his forehead was never obliterated. Almost dying, Lieutenant Colby was carried to the house of Mr. Dawson, when the local surgeons at once amputated the hand; and it was also proposed to resort to the hazardous operation of trepanning, but this design was abandoned. A constitution of unusual strength at length enabled him to triumph over the effects of this appalling accident, and he was mercifully restored once more to health; but it is impossible not to recognise in the injury inflicted on his skull, a sufficient cause both for subsequent bodily ailments, and for a reluctance to enter on long-continued mental exertion. At this point it seems desirable to pause, and to take a brief retrospect of the Ordnance Survey before General Colby succeeded Major-General Mudge as its superintendent.

Major-General William Roy, R.A., F.R.S., A.S., remarks that "Accurate surveys of a country are invariably admitted to be works of great public utility, by affording the surest foundation for almost every kind of internal improvement in time of peace, and the best means of forming judicious plans of defence against the invasions of an enemy in time of war." And hence it is that the difficulties experienced in war from a want of accurate maps, and a consequent defective knowledge of the country, to be included within a chain of military operations, has often led to the commencement of such works. The Scotch Rebellion of 1745, which was finally suppressed by his Royal Highness the Duke of Cumberland at the Battle of Culloden, pointed out the propriety of exploring and mapping the wild Highland districts, with a view to the establishment of military posts and roads of communication. In 1747 a body of infantry was encamped at Fort Augustus for this purpose under Major-General Lord Blakeney; and the plan of a survey suggested by Lieutenant-General Watson, then Deputy Quarter-Master General in North Britain, was undertaken by General Roy, R.A., then Assistant Quarter-Master General, and the work was at length extended from the Highlands over the whole mainland of Scotland. This work was never published, and having been carried on with inferior instruments, was merely considered by General Roy "a magnificent military sketch." The war of 1755 put a stop to these works of peace; but at the peace of 1763 the subject of a general survey of Great Britain, which would have included the work already done in Scotland, again engaged the attention of Government, and was again thrown into the shade by the troubles which preceded, and ended in, the American War. The peace of 1783 again restored that tranquillity which is equally necessary for the consideration as for the execution of such works: and at this critical period (October, 1783) a memoir of M. Cassini de Thury, on the great advantages which would be derived by astronomy from the connection through trigonometrical measurements of the two great observatories of Greenwich and Paris, and the consequent determination of the exact differences between their latitudes and longitudes, was submitted to the British Government by Count d'Adhemar, the French ambassador. The French had already carried a series of triangles from Paris to Calais, and it was only necessary that the English should complete the work by carrying a similar series from Greenwich to Dover. Mr. Fox, by the King's command, transmitted this memoir to Sir Joseph Banks, President of the Royal Society, and at his request General Roy charged himself with the undertaking, his Majesty George III. having expressed his warm approbation of the scheme, and supplied the funds necessary for the operation. The site of the initial base of this work, which must be considered the germ of all future scientific surveys of the United Kingdom, was fixed at Hounslow Heath; and, in this case also, soldiers—a party of the 12th Regiment—were employed to clear the ground, to protect the instruments, and to assist in the operations generally. Several modes of measuring this base were proposed and tried: the first was a steel chain, 100 feet long, constructed by Mr. Ramsden, on the principle of a watch chain, each link being one foot long, and constructed of three principal parts, namely, a long and two short plates with circular holes at the ends of each, by which they were connected together by steel pins, adjusted to and passing through the holes. The second method was by deal rods, in imitation of similar measurements on the continent; and three such rods were made of Riga red pine, being each twenty feet three inches long, reckoning from the extremities of their bell-metal tippings, two inches deep, and one-and-a-quarter broad, and which, being trussed both vertically and laterally, were sensibly inflexible. The third method was by glass rods, a suggestion of Lieutenant-Colonel Calderwood, of the Horse Guards, F.R.S.: three such rods, or rather tubes, were made, each twenty feet long, and inclosed in a wooden case eight inches deep, to the centre of which the tube was firmly fixed, the ends being left free to move in a longitudinal direction. The effect of trussing was produced on the cases by making them wider at the centre than at the ends, so that the sides were curved or arched.

It would appear from General Roy's statement, that the construction of the steel chain by Ramsden was undertaken experimentally, and rather with a view to obtain a useful instrument for future measurements, than for the determination, by it alone, of the length of this primary base. The deal rods, on the contrary, seem to have been relied upon, as that system of measurement had been before adopted on the continent; but it was soon found that the variation in length consequent on hygrometric changes in the atmosphere, was very considerable. In an experiment, after a week of rain, the rods were found to have gained in length one-fifteenth of an inch, which would have made a difference of seven feet and a-half in the whole length of the base: in another, 300 feet were measured in one day, and the rods, being left during the night on the grass exposed to a heavy dew, the measurement was repeated the next morning, when the length of the 300 feet line exceeded that of the previous day by nearly half an inch, which would have amounted to a difference of 45½ inches on the whole base. The great uncertainty consequent on such great and frequently very sudden changes led to the suggestion of the glass rods, with which the base was ultimately measured; though at the same time General Roy did not omit the opportunity of making a direct comparison between them and the steel chain, by measuring the same 1000 feet with both, and the result was very satisfactory, as after making the proper reductions for temperature, the difference between the two measurements was only ·021 of an inch, equivalent to a difference of little more than half an inch on the whole base. Though the limits of a memoir of this description preclude the possibility of describing in detail these most interesting instruments, or explaining even the various modes of using them, and especially of determining the contact between successive rods, such as coincidence of lines, actual contact of the metal-tipped ends of the deal rods, &c., it is right to notice briefly the ingenious method adopted in the glass rods: corks were introduced into the ends of the rods, which received and held fast a tube of brass, closed at the inner end, and open outwards; to the brass plate, or end of one of these tubes, was attached by a steel pin a brass neck, which exactly fitted the tube, and was terminated by a brass button which rested against the end itself of the glass rod, whilst in the other tube the connecting pin is free, and acts by a collar on a spiral spring, so that when the rods were brought together, the brass neck and button of one remained fixed, whilst the brass neck of the other tube readily slided inwards against the spring, until the cross lines on an ivory scale attached to it exactly corresponded with a fine line on the inner surface of the glass tube. This method of effecting contact is in itself very simple, and might, with the necessary modifications, be advantageously adopted under various circumstances, and especially with deal rods; and it may be added that the military engineer, when called upon to execute surveys in distant countries, will generally find that wooden rods must be resorted to, nor need he have any apprehension of the results if he only takes care to counteract their defects by either coating them with proper varnishes, or by filling their pores with any of those substances which will form an insoluble compound with vegetable matter. Some experiments for this purpose, with Kyanised wood are required: as it would at all times be easy to supply our foreign stations with such materials, and with sappers at hand, there could be no difficulty in constructing rods. The length of the Hounslow Base, as measured by General Roy, was, when reduced to the level of the sea 27,404¾ feet, or about 5⅕ miles; and the operation of measuring was attentively watched by the President of the Royal Society, and many of the leading scientific men of the day, and honoured on one occasion by the presence of his Majesty George III. The only officer of the Ordnance corps who was associated with General Roy in this work, and he as a volunteer, was Lieutenant-Colonel Pringle, Royal Engineers. The works thus commenced by the measurement of a base, though designed more immediately for ascertaining the relative situations of the observatories of Greenwich and Paris, had always been considered to have connected with it a still more important object, namely, that of laying the foundation of a general survey of the British Islands. For the first of these objects, a chain of triangles, the angles of which were measured by a circular instrument, or theodolite, 3 feet in diameter, constructed by Ramsden, was carried from the Hounslow Base to Dover, being connected with the Greenwich Observatory at one end, and at the other with a base of verification measured on Romney Marsh. The measurement of this second base was entrusted by General Roy to Lieutenant Fiddes, Royal Engineers, and Lieutenant Bryce, Royal Artillery, (immediately afterwards transferred to the Royal Engineers, and subsequently, as Sir A. Bryce, Inspector-General of Fortifications) and it was executed with the steel chain of Ramsden, (the efficiency of which had been, as before stated, tested by direct comparison with the glass rods) as being better fitted for use in such ground. The length of the Romney Marsh base after reduction, was found to be 28532·92 feet, or rather less than 5⅓ miles, and differing only a few inches from its length as determined by triangulation from the Hounslow base. The English triangulation was then connected with the French by observations from both sides of the channel, and thus the data were obtained for deciding the relative positions of the two great national observatories; but on this occasion it is manifestly impossible to enter into any discussion either of its merits or of the results obtained. In addition to the great triangles, a great number of secondary triangles were observed, which became a sure foundation for the topographical survey of Middlesex, Kent, &c. In September 1788, General Roy completed this great work, and returned to London, in very indifferent health; in 1789 his illness so increased that he was obliged to pass the winter of that year at Lisbon; in April 1790, he returned to England, and died before the printing of his paper in the Philosophical Transactions had been completed, though he lived sufficiently long to correct all but the *three last sheets* of that most detailed and able account both of the instruments he used and of the nature, objects, and result of the operations he so successfully carried out. His works alone can here be cited; and it is therefore with regret that the name of General Roy must be now passed by, without any attempt to do justice to his memory further than this brief record of the labours of the earliest British geodesist may have contributed to that object. Associated with General Roy in all his operations, was Mr. Isaac Dolby, of whom General Roy had the highest opinion, and this eminent mathematician, who became afterwards Professor of Mathematics to the Military College, was, as it were, a connecting link between the preceding and the successive stages of this great work. Nor ought the name of the Duke of Richmond to be here passed over without some testimony to his memory and merits. General Roy particularly acknowledged the attention the Duke always paid to his representations; and it is from him that the great work of a national survey obtained its earliest and most decided support. Taking, then, into consideration the encouragement he conferred on this peculiar branch of the ordnance service—asserting, by so doing, the claims of ordnance officers to be looked upon as scientific men—the patience with which he investigated the now popular subject of national defences, and the personal attention he bestowed on all the military departments of the Ordnance, including the Royal Military Academy, it may be justly said that the Duke of Richmond stands in the first rank of Masters-General of the Ordnance.

After General Roy's death the subject of a survey seemed, for a time, to be overlooked; but the Duke of Richmond being informed that Mr. Ramsden had constructed a second three-feet theodolite, and two 100 feet chains, of great excellency, recommended to the Government that they should be purchased, and the work renewed, and this recommendation was successful. The first operation was a remeasurement with the new chains of the base on Hounslow Heath, and the result of this second measurement commencing August 15th, and ending September 26th, 1791, differed only from that of the measurement with glass rods $2\frac{3}{4}$ inches in excess. The new chains differed from the original steel chain made for the Royal Society, and before described, in this, that instead of consisting of 100 links of 1 foot, they were composed of 40 links only, each link being a parallelopipedon, $2\frac{1}{2}$ feet long, and half an inch square—a construction of great strength, and less liable to be affected by small irregularities in the supporting troughs or coffers, than a chain consisting of short links. At this stage of the proceeding, that simple, but most essential requisite, a safe observatory tent, was devised and constructed at the Tower: it was octagonal, and consisted primarily of an internal skeleton of eight iron pillars, bound together by oak braces, and supporting a roof consisting of eight rafters united together at the top and clamped at the bottom to the iron pillars. The sides and roof were composed of frames covered with painted canvas, and the whole covered with a strong tent. This construction was afterwards slightly modified, and then continued in use till the period of the Irish triangulation, when it was still further modified and improved. The spring waggon, which has always proved so effectual in the transport of the great instrument, and has tended so materially to preserve it from injury, was now invented and constructed. The stations having been selected by Captain Mudge and Mr. Dalby, the triangulation was extended, in the years 1792-93-94, southward to the Isle of Wight, and connected with the previous triangulation of Kent, so that the groundwork was laid for the survey of a most important section of the country, and data obtained for important philosophical deductions. The operations closed in 1794, with the measurement of a base of verification on Salisbury Plain. This base was measured with the steel chains, and was found to be 36574·4 feet long, the length, as obtained by triangulation from the Hounslow Heath base, being 36574·3, exhibiting, therefore, a difference of little more than an inch in a length of nearly seven miles. The direction of the meridian was determined at Dunnose and at Beachey; but it is unnecessary to enter on this occasion into the calculations of the length of a degree of a great circle perpendicular to the meridian, in the latitude of 50° 41′, which were founded on these observations. The operations of these years were conducted by Lieutenant-Colonel Edward Williams and Captain William Mudge, Royal Artillery, and Mr. Isaac Dalby, and the results published in "The Philosophical Transactions," in 1795. The same gentlemen continued to conduct the work, and in 1797 was published an account of the operations of 1795 and 1796. In these years the triangulation was continued westward, so as to embrace the whole southern and western coast, and means adopted to fill in the great triangulation by a minor triangulation, the angles of which were observed by a smaller theodolite, eighteen inches in diameter, constructed by Ramsden, on the same principles as the great three-feet theodolites he had before made. This latter instrument was therefore taken into Kent to complete the materials for the survey of that county, by Mr. Dalby, and Mr. Gardner, Chief Draughtsman in the Tower, who then commenced his connection with a work in which he long continued a most valuable assistant, whilst a series of triangles was observed with the great instrument, extending from the Isle of Thanet, in Kent, through the counties of Dorset, Devon, and Cornwall, to the Land's End, and even connecting the Scilly Isles with the mainland. The Marquis of Cornwallis was now Master-General of the Ordnance, and the work appears to have assumed the distinct character of a national survey. The name of Lieutenant-Colonel Williams does not appear in connection with it after the publication in "The Philosophical Transactions," in 1797, of the results of these two years' operations. In this paper, Dr. Maskelyne gives the demonstration of that practical rule for reducing the observed angles to angles of the chords, which was so long used in the British survey. In 1800, Captain William Mudge, then chief director of the work, communicated, by order of the Duke of Richmond, an account of the triangulation and survey in the years 1797-98-99. In this paper it appears that the Ordnance map of Kent had then been published, that the survey of Essex, portions of Suffolk and Hertfordshire, Sussex, Hampshire, and the Isle of Wight, were, under the direction of Mr. Gardner, in a forward state, and that the Master-General had directed the survey of Devonshire and such portions of Somersetshire and Cornwall as were necessary to square the work to be undertaken. Mr. Isaac Dalby, worn out with the fatigues of this arduous service, now retired, and was succeeded by Mr. Simon Woolcot. The Royal Society having lent to the Ordnance the great circular instrument, or theodolite, which had been used by General Roy, it was determined to use one of the great instruments in completing the triangulation necessary for the surveys thus ordered by the Master-General; and the other in carrying through the country the meridional line already commenced. In 1797, the operations were principally confined to the determination of the direction of the meridian by observations of the Pole Star, at Black Down in Dorsetshire, Butterton, and St. Agnes' Beacon; and horizontal angles at a number of stations required to connect them with the meridian stations. The operations of 1798-99, included a considerable number of observations made for topographical purposes, and were therefore chiefly conducted by the chief draughtsman and surveyors of the Tower, under whom the actual survey was carried on; and also the measurement, in 1798, of a base on King's Sedgemoor, Somersetshire, in which a chain of 50 feet, made by Ramsden, was combined with the longer chains, and found very useful in facilitating a measurement over ground intersected by numerous ditches. The length of this base was 27,680 feet; but from the soft and shaky character of the ground, Captain Mudge considered it subject to an error of not less than six or more than nine inches, and it was found that the length of the base, as determined by triangulation from that of Salisbury Plain, differed from the measured length by *nearly one foot*. The account of all these operations was accompanied by a great number of latitudes and longitudes of stations, deduced geodesically from the calculated distances and meridional bearings. Hitherto the survey had done little towards the great astronomical question of the figure of the earth, although this object had always been present to the minds of its successive directors, and a new instrument, a zenith sector, had been several years before ordered from Mr. Ramsden by the Duke of Richmond, for the express purpose of being used in the celestial observations required in such an inquiry. This instrument was at length completed about the end of 1801, by Mr. Berge, Mr. Ramsden dying just before he had put the last touch to it. It was the intention of Major Mudge to apply the extension of the survey triangulation northwards to the determination of an arc of the meridian, extending from Dunnose to the mouth of the Tees; and in 1802 the triangulation had been carried so far as to enable him to comprise within his celestial observations an arc of 2° 50′ 23″·38, extending from Dunnose in the Isle of Wight, to Clifton in Yorkshire; the sector having been observed at both these stations, and at Arbury Hill between them. This remarkable instrument was provided with a telescope 8 feet long, supported at its summit by means of a conical axis, on the Y's of a strong frame, and with a graduated arch 15° in extent, struck by the telescope as a radius. It admitted therefore of observing stars 7° 30′ on either side of the zenith. The instrument admitted of reversal in the plane of the meridian, and great ingenuity was displayed in all the arrangements for adjusting the plumb-line, for relieving the axis from pressure, for securing stability, and for facilitating the operations of observing, reading, &c.; and it was therefore naturally expected that with an instrument provided with an arch of so large a circle, the results of observation would be very superior, and most important data be obtained for comparison with the measurements of other countries; but it is remarkable that the results proved at variance with the deductions from other measurements, as the length of a degree increased in approaching the equator in the following manner :—

| | Latitude. | Length of degree in fathoms. |
|---|---|---|
| Middle point between Arbury Hill and Clifton . | 52° 50′ 30″ | 60,766 |
| Middle point between Dunnose and Clifton . | 52 2 20 | 60,820 |
| Middle point between Arbury Hill and Dunnose | 51 35 18 | 60,864 |
| Middle point between Dunnose and Greenwich | 51 2 54 | 60,884 |

General Mudge did not conclude from these unexpected results that the earth was an irregular solid of revolution, and still less did he deduce from them an argument against the Newtonian theory of its figure; on the contrary, he explained them as the effects of deflections of the plumb-line of the sector, consequent on an unequal attraction due to the irregular distribution of the matter in the vicinity of the sector stations. It cannot indeed be doubted that all instruments of which the vertical adjustment depends on a plumb-line or any other contrivance, subject to be influenced by the force of gravitation, must more or less be exposed to this source of error, though at the same time it appears possible by a judicious combination of observations, as for example, by observing at subsidiary stations to the north or south of the suspected station, and at short accurately measured distances from it, to detect if not to avoid the error, and to determine its amount and direction. All geodesists did not however concur in opinion with General Mudge, and in 1812 a paper was published in the "Philosophical Transactions," by Don J. Rodriguez, in which that writer endeavours to show that the possible errors of the sector, as exhibited in the various readings of the same zenith distances, are sufficient to explain the observed anomalies; and the mode in which he conducts his investigation is curious. He first assumes an ellipsoid for the earth's figure, depending on the compression or ellipticity deduced from the various measurements of degrees in northern and southern latitudes, independent of the English, and then, with the calculated distances and observed azimuths published in the account of the English survey, determines by calculation the length of the meridional arc in feet or fathoms, and deduces from that length and the elliptic elements the length in degrees, minutes, and seconds. Comparing this length as deduced from calculation with that obtained by the sector observations, he maintains that the difference is not beyond the limits of error of the instrument. Don Rodriguez, in conducting this comparison, adopts successively three different compressions, so as to get rid of any probable error in their determination, namely, $\frac{1}{330}$, $\frac{1}{320}$, $\frac{1}{310}$; and to prove the applicability of his method, makes a similar comparison between the observed and the calculated lengths of Svanberg's Arc in Lapland, and Lambton's Arc in the East Indies, in both of which calculation and observation were found to be in perfect accordance. The last publication of the proceedings of the survey, with which General Mudge was connected, was dated one year before the paper of Don Rodriguez; and it does not therefore appear that his remarks were ever replied to by General Mudge, though it must be admitted that they merited consideration, and seemed to render necessary fresh observations of zenith distances at the great sector stations, in order to confirm their accuracy and to support their testimony. When it is remembered that Don Rodriguez adopts an ellipsoid which had been determined from a comparison of the northern and southern degrees, it cannot be considered remarkable that, with that ellipsoid, he should again arrive, by calculation backwards as it were, at those degrees; and though the difference between the observed English arc and the arc as obtained by calculation on Don Rodriguez's system does not much exceed the difference between some of the individual observations, it would be quite unreasonable to consider the whole of the extreme differences between the observations as due to error. In most cases the mean of a set of angles is more likely to be correct when by their variations they embrace every cause of error, than when they are all apparently identical in reading, though probably only so because they have been affected by the same errors acting in the same direction; still, however, when the demonstration of a remarkable physical fact seems to depend on the right interpretation of observations, no doubt ought to be allowed to remain of their accuracy and efficiency.

Up to this time the proceedings of the Ordnance Survey had been first recorded in the Philosophical Transactions, the usual reports having been submitted from time to time to the Royal Society, by desire of the Master-General; and several reasons might be advanced in favour of this system, as it admitted of the publication of small portions of the work at moderate intervals of time, placed the results of observation and calculation in the hands of the most scientific men, and distributed them to all parts of the country, every Fellow of the Royal Society receiving a copy of the Transactions; and, further, it maintained that connection between the conductors of a great scientific work and those persons who are necessarily the best judges of its excellence, which it is most desirable should never be abandoned. On the other hand, the publication of the proceedings of the Survey as a distinct work, is more consistent with the position and character of a great national establishment, though it may be feared that it has hitherto narrowed the sphere of its utility by restricting a knowledge of what has really been done to those few persons who have chosen to purchase an expensive work, or have taken the trouble to examine it at the libraries of the Royal Society or British Museum. It would appear, however, very easy to secure the advantages of both these systems of publication; and, in doing so, to restore at once the connection between the Survey and the Royal Society on the one side, and that between the Survey and practical men of science on the other, by a modification which would approximate the system more to that of the United States' Survey. The system suggested is this:—That purely scientific matter, such as the measurement of an arc of the meridian, the measurements of bases, the determination of the greater triangles, the description of new instruments or of new modes of calculation, should be recorded, as formerly, in the Philosophical Transactions; but that all matter of a practical bearing—such as the latitudes and longitudes of stations, whether primary or secondary, the calculated distances between the stations (and especially between those of a permanent and easily recognisable character, such as church steeples, tall chimneys, windmills, &c.), and the elevations of objects, classified according to their probable accuracy as depending upon the mode of determination, and being subject to a possible error of six feet, or of three feet, and so on—should be published either annually or biennially in a cheap octavo form, so as to be sold by the agents for the sale of the maps at a very low rate, and thus put into the hands of every one interested in such matters. This suggested method would, it is presumed, do away with that insulation of the Survey which renders it unpopular with practical men, and by making its results known without delay to the civil engineer, the surveyor, or even to the landed proprietor, would enable any one of them to apply them to his own purposes and in his own way; and, further, let it be added, that such a system would show that the conducters of the Ordnance Survey were not only desirous to co-operate with other practical men, but that they courted for their work the most rigorous examination and criticism.

The first account of the Trigonometrical Survey, published as a distinct work, appeared in 1811, and embraced the operations of the years extending from 1800 to 1809 inclusive; but previously the several reports in the "Philosophical Transactions" had been republished in a similar manner, and now formed, together with the last one, a work of three volumes, of which that of 1811 was the third. This last volume is stated to be by Lieut.-Col. William Mudge, R.A., F.R.S., and Captain Thomas Colby, Royal Engineers, so that the services of the latter had already been fully appreciated by his able chief in this great work. In 1801 a base line 26342·7 feet in length, was measured in the north of Lincolnshire, on Misterton Carr, and General Mudge laid down as a principle that a new base ought to be measured at each distance of 100 miles in the direction of the arc of the meridian, so as to serve as a base of verification for the work preceding, and an initial base for the work following it; a principle, however, which must be necessarily modified by the nature of the triangulation, and specially by the magnitude of the triangles. The Misterton Carr base served therefore for the extension of the work northward, whilst that measured in 1806 on Rhuddlan Marsh, near St. Asaph, in North Wales, was equally necessary for its extension westward, through the central portion of the kingdom. This base was 24514¼ feet in length; and when the measured length was compared with that obtained by calculation, both from the bases of Hounslow and Misterton Carr, the results were highly satisfactory, as the difference did not exceed 1 foot. In the same year observations of the zenith distances of several stars were made at Delamere Forest in Cheshire, and at Burleigh Moor near the mouth of the Tees, Yorkshire; and the direction of the meridian was determined by observations of the polar star at both stations. From the data thus obtained and the calculated distances of the triangulation, the meridional distances between the parallels of Dunnose and Burleigh Moor, and between the parallels of Dunnose and Delamere Forest were deduced, and compared with the amplitudes of the celestial arcs as observed. In the one case the meridional arc was 3° 57′ 13″, and in the other 2° 36′ 12″. The length of the degree at the middle point between Dunnose and Burleigh Moor is determined to be 60823·8, in the latitude 52° 35′ 45″; whereas, as observed by Colonel Mudge, the length of the degree by the observations and calculations of previous years had been determined to be 60820 fathoms, or only about 4 feet difference—though, according to the ellipsoidal theory, the length of a degree in latitude 52° 34′ should have been 60830 fathoms, that of a degree at 52° 2′ having been taken as 60820, a difference which shows that there is much to reflect upon in the determination of the value of this arc. The rest of this volume contains a large mass of most useful materials in triangulation primary and secondary, in computed meridional distances, and in latitudes and longitudes. As Lieutenant Colby joined the survey at the early age of seventeen years and four months, the period noticed in this volume must be considered his novitiate, and he could therefore only have been expected to act in conjunction with, and under the immediate direction of, Major Mudge. He seems, however, to have rapidly advanced in utility and in the esteem and confidence of his superior officer. In June, 1802, a few months only after his connection with the survey had commenced, he was observing at Dunnose, and on the occasion of his dreadful accident in December, 1803, Major Mudge thus writes to General Morse, then acting Chief Royal Engineer—"I deferred addressing you on the subject till my arrival at Liskeard, for I was apprehensive that, with a relation of the accident, I should have to report his death. It is, however, with a degree of satisfaction proportionate to my regard for this most excellent but unfortunate young man, that I have to state the confident expectations entertained of his recovery,"—terms in an official letter which mark no ordinary warmth of feeling. In 1804, he was observing the Pole Star for azimuths, at Beaumaris; in 1806, observing with the zenith sector, at Burleigh Moor and Delamere Forest; and in 1811, he was in South Wales actively engaged in selecting and fixing stations, so that he had then, under the direction of General Mudge, taken part in every one of the great operations of the survey, the base on the Rhuddlan Marsh having also been measured within the period now under notice. The appointment of Lieutenant-Governor of the Royal Military Academy was conferred on General Mudge (then lieutenant-colonel) in July, 1809, and from that time the executive duties of the survey were principally performed by Captain Colby, though, from the want of a published account, it is not easy to trace accurately his movements. His military progress was as follows: first lieutenant, 6th May, 1802; second captain, 1st July, 1807; captain, 5th March, 1812.

In July, 1811, Lieutenant-Colonel Mudge addresses Captain Colby (from Brighton) at Brecon, and communicates to him doubts expressed by Captain Hurd, Hydrographer of the Admiralty, as to the longitudes and latitudes of some important coast points—"Ponder," he says, "the contents of his letter, and when you can speak decidedly on the question, let me hear from you. I think the latitudes and longitudes of the Smalls Lighthouse, and Gresholm Isle, as given in the account, are right; I have not a copy of the work by me, or I should perhaps be able to determine the matter myself. I think you told me, on one occasion, that Gresholm Isle was not rightly fixed by the triangles first given. It is of consequence that Captain Hurd should be either proved wrong, or that the errata he has discovered may be acknowledged to be such, and these errata put to rights;" an extract which proves the important position then occupied by Captain Colby, and the early attention he had paid to the correctness of the survey work. At this time Lieutenant-Colonel Mudge appears, from his letters to Captain Colby, to have been much distressed by a delay on the part of the Master-General and the Board, in sanctioning the publication of the account of the survey by Mr. Faden, and it is not unlikely that the recollection of these difficulties subsequently operated on General Colby's mind in checking an inclination to renew the subject of publication.

Another source of anxiety was the inquiry of "the military commissioners," before whom Colonel Mudge was summoned in his double capacity of Lieutenant-Governor of the Royal Military Academy, and Superintendent of the Survey. In his letters of September 2nd and October 1st (1811), the general results of this examination is stated to have been favourable, as he observes, "I am certain they were impressed with an idea of the extreme accuracy of the work," though it would appear that he expected from the commissioners some strong animadversions "on the apparent magnitude of the sum" expended upon it. The total expense of the work, for the first twenty years, from 1790 to 1810, as stated by Colonel Mudge, was as follows:—

| | | |
|---|---|---|
| Triangulation | £21,000 | for the whole twenty years. |
| Interior survey | 25,347 | from 1800 to end of 1810. |
| Engraving | 7,818 | from 1801 to end of ditto. |
| Total | £54,165 | |

Or if the average be taken upon the whole period, an annual expense of 2,208*l.*; and if the average be taken on the last ten years only, which is more correct, an annual expense of 4,416*l.*—a sum very different from that assigned by public rumour, an anonymous writer having published a statement that "the expenses of the survey had exceeded 10,000*l.* per annum!" In Colonel Mudge's letter of November 5th (1811), it is stated that an application had been made by the Quartermaster-General, to have the plans drawn from the survey sent to the Horse Guards, to be there *copied* for the use of his department. This measure was advocated by the Duke of York, and it was afterwards arranged that the plans should be sent to the Horse Guards in parcels of four, five, and eight, in succession, until the whole had been copied, and that this arrangement should apply to the future maps as well as to those already finished. After the publication of the account of the survey, in 1811, it was determined to prolong the meridional line into Scotland, and the triangulation of the mountainous districts of that country opened out a new field for the display of those personal energies for which Captain Colby was so remarkable. On the 9th September, 1813, Colonel Mudge writes—"I have now to beg you will send me, upon a sheet of paper, a sketch of your triangles, with your meridional line laid down thereon, telling me when you give up the business; and you will now hear with great satisfaction the probability of my returning with you to the north next spring, to finish our operations, for my health is much restored, and though I write by the hand of another, yet I am in many respects better than I have been for some years;" and he closed this letter with the passage of grateful eulogium on the services of his assistant and friend, which has already been quoted. The mind of Colonel Mudge was at this time much harassed by the attacks of various critics, some of whom gave their names and others wrote anonymously. The paper of Don Rodriguez may be said to have led the way in this attack, although a candid reader of the present day will, it is believed, find nothing in that paper but a fair expression of doubt as to the sufficiency of the evidence afforded by the zenith sector observations for the determination of a great physical question. At the time, on the contrary, it seems to have been considered and treated as a personal and invidious attack either on the superintendent of the survey, or on the survey itself; and this mistaken feeling is strongly manifested in the letter which has been here quoted, whilst directing the attention of Captain Colby to a critical essay in the "Edinburgh Review," ascribed to Professor Playfair, on Colonel Lambton's reports on the Indian Survey. It is refreshing to observe the calm and candid tone in which Playfair examines the subject, in reference to the meridional arc measured in England. He first gives the various lengths of a degree determined by Lambton, as deduced from parts of the general arc of about three degrees—

| | Fathoms. | Middle Lat. |
|---|---|---|
| Punnae and Putchapoliam . . . . | 60473 | 9° 34′ 44″ |
| Punnae and Dodagoontah . . . . | 60496 | 10 34 49 |
| Punnae and Bomasundrum . . . | { 60462 | 11 4 44 |
| Punnae and Panghur . . . . . | { 60469 | 11 8 3 |
| Mean of the two last . . . . . | 60465·5 | 11 6 23·5 |
| From a former measurement . . . | 60494 | 12 32 0 |

And then pointing out that the same anomalies appear in these results as had been noticed in the measurements both of France and England, and especially in those published by Colonel Mudge, he observes, that "such anomalies will probably always occur where contiguous parts of the same arch are compared with one another. The degree in the parallel of 11° 6′ 23″ is less than that in the parallel of 9° 34′, a degree and a half further to the south. This is similar to what appears in the degree in England; and there is an instance of the same species of retrogradation, when the parts of the arch between Dunkirk and Formentaro are compared with one another. Some part of this irregularity, but *certainly a very small one,* may be ascribed to error of observation; the greatest part must, we think, be placed to account of the irregularity in the direction of gravity, arising from the irregularities at the surface or in the interior of the earth; the attraction of mountains, for example, or the local variations of density in the parts immediately under the surface. We long ago remarked, in speaking of the Trigonometrical Survey of England, that it *would have been of great* *importance to have added to it a mineralogical survey,* as the results of the latter might have thrown some light on the anomalies of the former. The same thing is suggested by the objects now under consideration. It would be extremely desirable also to have a vertical section in the direction of the meridian and of the perpendicular, at those places where observations for the latitude are made. This might afford a satisfactory solution of many difficulties which at present are sufficiently perplexing, and seem to increase just in proportion to the extent and accuracy of the observations." This admirable suggestion was subsequently advocated warmly, both by Colonel Mudge and Captain Colby, and the result was the appointment of Dr. M'Culloch to act as mineralogical surveyor, in connection with the survey of Scotland. Major Lambton had found the length of a degree in latitude 11° 59′ 54″, equal to 60529 fathoms, by one set of deductions, and by another 60449; and as the stations from which these results had been obtained were sufficiently remote from mountains to remove all suspicion of a disturbance from that cause, although the existence of *some disturbance* was undoubted, he attributed it to the effects of a bed of iron ore which had drawn the plummet northward at Dodagoontah, and southward at Bomasundrum, so as to give the celestial arc between Dodagoontah and Putchapoliam (to the south of both the other stations) too little, and that between Putchapoliam and Bomasundrum too great—a case quite analogous to that of the English arc. "The anomalies," as Playfair goes on to observe, "which have occurred in the measures of degrees, and of which the appearances seem to increase in proportion as greater pains are taken to avoid inaccuracy, have naturally drawn the attention of mathematicians; and the question, what part of them is to be ascribed to error, and what to irregularity in the structure of the globe, has come, of course, to be considered. That a small part of them only can be ascribed to the former cause, is rendered probable by the very circumstance just stated; that they are not diminished, nay, that they even seem to be increased, by the care taken to avoid error. It seems clear from that consideration that the irregularities are in the object sought for, and are only brought more in sight by more microscopical observations, by the excellence of the instruments, the accuracy of the computations, and the extent of the lines measured." But though Playfair ascribed the fact that, in Colonel Mudge's arc the degrees appear to increase on going from the north to the south, to local irregularities in the direction of gravity, and not to instrumental errors, he characterises the paper of Don Rodriguez as being written with great knowledge of the subject, and full of sound mathematical reasoning, notwithstanding that it takes the opposite view of ascribing the irregularities in the arc to errors of observation. "Don Rodriguez," he observes, if we mistake not, "is one of two Spanish gentlemen who accompanied MM. Biot and Arago, and assisted in the operations by which the meridian that had been traced through France was extended to the southernmost of the Balearic Isles. He seems perfectly acquainted with the methods of calculation, and all the most recent improvements which respect the problem of the figure of the earth. We do not think that he has proved that the irregularities in this measurement arise from errors of observation; and we are of opinion, though their amount may now be more exactly estimated than before, that with regard to their cause, the question rests precisely where it did. But though we are not convinced by Don Rodriguez, we must do him the justice to say, that his argument is fairly conducted, and that he has displayed great knowledge of the subject, and perfect familiarity with the best methods hitherto employed in the solution of this difficult problem. We have therefore observed with regret, that this ingenious foreigner has been attacked in some of the English journals with a violence and asperity which the subject did not call for, and which his paper certainly did not authorise." This just and candid criticism did not quite satisfy Colonel Mudge, who appeared to think that the Edinburgh Reviewer was unwilling to allow any other hand than his own "to wield the tomahawk" of criticism; but it is impossible, at the present day, not to concur with Playfair in thinking that Dr. Olinthus Gregory, to whom his remarks applied, was *quite unjustified* in such a system of defence, and rather injured than assisted Colonel Mudge, by adopting it; and that Playfair wrote with no ill-feeling towards the survey or its managers, may be fairly deduced from his closing paragraph.—"It is with pleasure, therefore, that we see a meridian, which has been extended from the shores of the British Channel along the west side of England, viz., the meridian of Delamere, now produced into Scotland, where it falls on the east side of the island, and is about to be continued till it intersects the shores of the Murray Firth, on the Northern Ocean. The combined arches in France and England will then extend nearly to twenty degrees; and in a few years we shall perhaps see the distance between the parallels of the Balearic and the Orkney Islands ascertained by actual mensuration. We believe that this important operation *could not easily be in better hands than those in which it is actually placed;* and, when it shall be completed, the British army—in General Roy, R.A., and the officers who have succeeded him in the conduct of the English Survey—and in Major Lambton, whose works in the Peninsula of India we have been now treating of, will have the glory of doing more for the advancement of general science, than has ever been performed by any other body of military men." A noble tribute of praise from such a man as Playfair, in comparison with which the ordinary articles of the public journals, whether written in defence or in attack, should have been regarded as mere dust in the balance.

Notwithstanding the little value attached by General Mudge to the remarks of Don Rodriguez, the subject was often present to his mind, and in May, 1814, he writes—"In reference to this matter, and still more in reference to the importance of satisfying the public mind, now very anxiously bent upon this point, I should have derived infinite satisfaction from the zenith sector being this year used instead of the circular instrument, and am sure I cannot see why it should not be so used, for I should be in that case enabled the sooner to put up the zenith sector on Arbury Hill, which I have promised to do, and certainly will do, to vindicate the memory of Ramsden." At this time the triangulation had been pushed into Scotland, and so earnestly intent was General Mudge on the repetition of the zenith sector observations in England, that he does not appear to have approved, in the first instance, of the project of extending the arc of the meridian to Shetland, which most probably originated in Captain Colby. In the same letter, he says, "Now, I beg of you most seriously to take into consideration, that it is my wish, if you can accomplish it, to finish the sector work this year (1814). What use is there in your going to Shetland with the sector? I can see none. Certainly there is none, for the arc will be long enough if ended upon the remote part of Scotland, short of the isles, and by causing us so to do a finale would be given to the sector. Let us not prolong it unnecessarily, but give a speedy finale to the meridional operations; the public very anxiously look for it." There cannot indeed be a doubt as to the great interest which naturally attached itself to this branch of the survey, and especially to the investigation of the causes which had led to apparent anomalies in the results; though at the same time it would perhaps have been a matter of regret to have curtailed the fine arc of more than ten degrees between Dunnose and Balta, which was obtained by continuing the work to, and making the last sector observations at, the latter station. By carrying out the design, however, General Mudge was disappointed in his hope of repeating the observations at Arbury Hill, as it was impossible, during his life, to apply the sector to such a purpose. So far, however, as the character of Ramsden's instrument entered into the question, it has been most satisfactorily vindicated by observations made with the new sector, an instrument constructed under the direction of Professor Airey, Astronomer Royal, on totally different principles, as may be judged from the following comparison, in which the finally corrected results (using all the observations and applying the best formula) of the old zenith sector are adopted :—

| | | | Latitude. |
|---|---|---|---|
| Dunnose, | by old sector, | observations | 50° 37′ 7·05″ |
| Ditto, | by new sector, | ditto | 50 37 6·98 |
| Cowhithe, | by old sector, | ditto | 57 41 9·47 |
| Ditto, | by new sector, | ditto | 57 41 9·58 |
| Balta, | by old sector, | ditto | 60 45 1·59 |
| Ditto, | by new sector, | ditto | 60 45 1·68 |

Examples of agreement between the observations of totally different instruments, taken at a considerable interval of time, not perhaps to be equalled by those of any similar geodesical or astronomical operations; and it may be added, that the fact of a deflection of the plumb-line at Dunnose, to the extent of about 3″, has been proved by observations near the station, taken somewhat in the manner pointed out in a preceding page of this memoir. The difficulties inherent to the determination of latitudes, as required for the estimation of the celestial amplitude corresponding to an arc on the earth's surface, had indeed been discussed by some of the most able observers, as few have escaped entirely from an apparent discordance, in some particular case, between the angular lengths of arcs determined geodesically and astronomically. An instructive example may be cited from the astronomical correspondence of Baron Zach, in reference to the survey in Tuscany, by the Rev. Father Inghirami, Professor of Astronomy and Director of the Observatories at Florence. This able and singularly candid man had provisionally founded his survey on a *very small* base, only 426 toises (931·7 yards), a little more than half a mile in length, measured by Baron Zach, and having most carefully conducted his triangulation and verified its results by several independent series of triangles, he attempted to determine geodesically the difference between the latitudes of the observatories of Pisa and Florence, when to his surprise he encountered the following discordant results. The latitudes of both these observatories had been determined astronomically, but starting from that of Florence, the geodesical and astronomical latitudes stand thus in contrast with each other—

| | |
|---|---|
| Geodesical by triangulation, from Florence, latitude . | 43° 43′ 19·4″ |
| Astronomical by 504 observations of Stars | 43 43 11·77 |
| Difference | 7·63 |

Now this difference was enormous, and would have implied an error of more than 200 yards in the measured arc, if such had been the cause of the discrepancy between the results. The first idea of Inghirami was to attribute the error to the small length of Zach's base, and he at once undertook the measurement of a much longer base in the great plain between Leghorn and Pisa. This base was 9824 yards, or more than five and a half miles in length, and the measurement was effected in two different modes; namely, by direct measurement with deal rods and by triangulation—a system which will be hereafter explained.

The following is a comparative view of a portion of the base thus determined :—

| | | | Feet. |
|---|---|---|---|
| By triangulation . . . | 10705·9 | Florentine . . . | 20499·8 |
| By actual measuring with rods | 10706·8 | Braccii . . . | 20501·7 |
| | 0·9 | | 1·9 |

Or nearly two feet in rather less than four miles—a difference not greater than that found in separate measurements of some English bases, and far too small to affect sensibly the general results.

Inghirami then proceeded to test the accuracy of his first deductions from Baron Zach's small base, by closing the triangulation, depending on that base, upon this newly measured base, when he found the distance between the belfry of S. Pietro in Grado, and the corner of the old ducal palace of Stagno, stood thus—

| | Feet. |
|---|---|
| By one chain of triangles . . . . . . . . | 29454·3 |
| By a second chain of triangles . . . . . . | 29449·7 |
| By direct measurement . . . . . . . . | 29449·9 |

This unexpected confirmation of his first results was not received by the worthy Father with the satisfaction which might have been expected, but, on the contrary, actuated by a totally different feeling from that which had influenced the English geodesists, he warmly expressed his regret that his work should have been thus placed in opposition to astronomical observations. "How," he exclaims, "shall I struggle against this most unexpected anomaly in the position of Pisa? It is a rock on which I must be wrecked, as no art can save me! I measured my new base with the hope that, connecting it with Pisa, on the one hand, and having the other base of reference at the other end of the chain, I might the better discover the cause of my error, but all has been in vain, as the new base tells precisely the same tale as the old. It is impossible to say whether I was more surprised or more vexed at this result, as one totally different was both expected and required to place my operations in accordance with the previous observations." Such, says Baron Zach, were the painful feelings which agitated Inghirami, on discovering this apparently inexplicable difference, just as M. Mechain had been distressed and worried by a similar case in France, and it may be added General Mudge, by that of the English arc. The causes of the strange differences which had been thus experienced by Maskelyne, Mudge, Lambton, Mechain, Schiegg, Inghirami, and himself, should, as Zach considers, be sought for in one of the three following causes, namely—

1. Errors in the instruments, or errors of observation.
2. Deflection of the plumb-line, or disturbance of the levels by local terrestrial attraction.
3. Irregularity of figure and of conformation of the earth.

As an example of the difficulty of accurately determining latitudes, even by the most excellent fixed instruments, Baron Zach cites the successive changes in latitude of Greenwich, viz. by Bradley, 51° 28′ 41·5″; Maskelyne, 40·7″; Bessel, by 2008 observations of Bradley, 39·56″; Pond, 38·5; to which may now be added Professor Airey's determination, 51° 28′ 38·3″; "so that 2000 observations and sixty-four years' work have not sufficed to settle the true second of latitude of the Greenwich Observatory. So long, indeed, as it is necessary to use plumb-lines or levels in the determinations of altitudes—and on them depends the determination of latitudes—it cannot be expected that we shall attain to the same precision as can be readily secured in horizontal angles, or that we can obtain latitudes by ordinary or moveable instruments within two or three seconds." Baron Lindenau, of Gotha, expresses himself even more strongly: "The zenith observations," he observes, "of M. Bessel, at Königsberg, which in themselves constitute so striking an accordance, give, nevertheless, declinations of the stars, which are less by 3·2″ than those of Pond, Piazzi, and Oriani;" and he adds, what has happened to Inghirami in his measurement in Tuscany, has similarly occurred in all great geodesical operations. In France it was necessary, in order to reconcile the results to a spheroid, the flattening of which was $\frac{1}{300}$ to suppose errors in the latitudes of Dunkirk, Evaux, Carcassone, and Montjouy, of 3·1″, 5·8″, 0·8″, 3·6″, and in England the results were still more discordant, as they represented an equatorial and not a polar flattening, and would have required a supposed error of 8″ in the latitudes, to reduce them to order."

In respect to the two other causes, whilst Baron Zach admits the probability of local attractions and disturbances of the plumb-line, rather from the unequal distribution and density of the matter below the surface, than from the action of hills projecting above it, he seems more disposed to ascribe the discrepancies experienced to irregularity in the form of the earth itself, and quotes the opinion of La Place to that effect. Baron Lindenau, on the other hand, rejects such explanations, and ascribes the difficulty of reconciling geodesical latitudes and longitudes with those determined astronomically, entirely to the defects of astronomical observations, partly resulting from the imperfections of instruments and partly from the defects of physical astronomy. It is not intended to enter here into a detailed discussion of this most interesting question, but it seemed only due to the reputation both of British artists and British observers that the true nature of the difficulties they had experienced, as well as their generality, should be made apparent. Two of the causes of such difficulties which have been cited, namely, first, the improbability of determining latitudes astronomically to the utmost precision by moveable instruments; and, secondly, the effects of local terrestrial attraction, cannot be reasonably rejected, as more or less influencing geodesical results; but it seems difficult to ascribe such great differences as those observed in England and Tuscany to irregularity in the figure of the earth alone, although it is highly probable that there is a certain amount of such irregularity. The more the physical condition of the earth is investigated, the more evident does it become that the matter immediately below its surface varies greatly from place to place, in its density and properties—a fact which is strikingly exhibited in respect to the progression of temperature on descending into the interior of the earth. Whilst, for example, under ordinary circumstances the temperature increases by about 1° Fah. in 55 feet, it was found, in a boring at Neuffen, in Wurtemburg, to amount to 1° in about nineteen feet—an indication of great internal heat, which could only be accounted for from the proximity of the boring to large masses of basalt, which still retained a very high temperature. Can it be doubted that such masses of very dense matter, only recently fused under enormous pressure, would be a powerful attractive force, and exercise a powerful disturbing action; and, further, that such masses may be subject even to change of position, and therefore may so vary in the amount of their action as to produce different results at different times? These considerations will assist the reader in appreciating the accuracy of observations and the difficulty in guarding them from the effects of disturbing causes. General Colby was concerned either as principal or assistant in all the sector observations on which the comparison between the terrestrial and celestial arcs had been or will be founded. With General Mudge he observed at Dunnose, Clifton Beacon, Arbury Hill, Delamere Forest, and Burleigh Moor, and, aided by Mr. Gardner, he conducted those of Kellie Law, Cowhithe, and Balta; and the zenith distances, taken at the same stations, with Airey's sector, were observed by Sergeant James Steel, of the Royal Sappers; so that the system of employing trained soldiers on this great work, introduced by General Colby, attained, during his time, its fullest development, and it may be cited, as a proof how entirely he was above the feeling of petty jealousy, that he thus directed his own personal observations, the observations of his most able days, to be tested by Sergeant (then Corporal) Steel. But though, in the abstract, this result was most satisfactory, it may be doubted whether General Colby contemplated, at first, so great an extension of his system, and whether, in fact, it has not now been carried beyond the limits of sound policy. The survey was considered by General Morse, as pointed out in a preceding paragraph, a fitting school for young officers, and it subsequently became, when extended to Ireland, a real and practical school for both officers and soldiers in every branch of surveying. Such a school it ought still to be, but when the officers are entirely abstracted from that class of observations with which it is most desirable that they should be familiar, it may be feared that they will never become either practical surveyors or practical astronomers; and though it is most gratifying to render the Sappers and Miners equal to the performance of every description of duty, the officers of Engineers should, at least, keep pace with them, and be prepared either to direct or to participate in their scientific labours. The survey, indeed, should be a field of operation for those officers who have distinguished themselves at the Royal Military Academy or at Chatham by their acquirements, theoretical and practical, in geodesical science, and it should afford to them the means and opportunity of perfecting themselves in every description of observation as well as of calculation.

In the volume of sector observations just published, Captain Yolland does not enter on a comparison between the geodesical and astronomical amplitudes of the great or complete meridional arcs, as he justly observes, that "such comparison will be more properly dealt with in discussing the results of the triangulation, when the question of the standards of measure employed at different times on the Ordnance Survey, and the elements for the figure of the earth used in computing the geodesical amplitudes, will have to be taken into consideration:" and adds, that the geodesical amplitudes he publishes must be considered only as approximative, "as at present they all relate to feet, in terms of the ordnance ten feet iron standard bar O, which there is no doubt is too short as compared with the standard used for the trigonometrical survey in England by Major-Generals Roy, Mudge, and Colby, and whose results have been employed by the Astronomer Royal, Professor Bessel, and others, in the determination of the figure of the earth." This comparison of the standards, or in other words, the determination of the actual unit of measure, was constantly present to the mind of General

Colby, when projecting and maturing his arrangements for the Irish survey; and its importance is so manifest, that it may be hoped the experiments there commenced will be completed; and the comparative values of the several scales used both at home and abroad accurately determined. Several very interesting comparisons are, however, given of the amplitudes of short arcs, and though in several of these there is a considerable difference between the astronomical and geodesical determinations, the difference varies so much both in amount and direction, that it would be impossible to account for it by any general irregularity in the form of the earth. Captain Yolland treats the differences as entirely due to local attraction, or to deflections either of the plumb-line or of the level, and in such a case as that of the amplitude between Cowhithe and Great Stirling, in which the geodesical is less than the astronomical amplitude by 9·48″, there cannot be a doubt that the larger portion of the difference must be due to local attraction, though some hesitation may be expressed in ascribing minute differences of 0·6″ to that cause entirely, when very considerable differences are observable in the latitudes of the same station, as determined from different stars; for example, in that of Ben Heynish, where the extremes are 56° 27′ 20·04″ and 56° 27′ 11·94″, even though the system of allowing to the several results a value proportionate to the number of observations of each star tends so materially to strike a correct balance. It may, however, be justly said of this last volume of the Ordnance Survey, which is in fact the last record of the labours of General Colby, as it contains very little which he had not ordered to be done before his separation from the work, that it exhibits great care and judgment in investigating, by the observations of collateral stations, the probability of local disturbances, and thereby assisting to free the terminal stations of the great meridional arcs from sensible errors. But Captain Yolland states "that General Colby, immediately after the construction of the new zenith sector, selected certain points for making observations from, so that in the determination of the figure of the earth by meridian measures, more than one arc of meridian should be available from the trigonometrical survey of the United Kingdom, for combining with the measures made in other countries;" and he thus added to the original meridional arcs one extending from Hensbarrow, in Cornwall, to Ben Hutisch, in Sutherlandshire, and another from the Hill of Forth, in Wexford, through the south end station of the Lough Foyle base to Monach in the Isle of Lewis, which has been subsequently extended southwards to a station near St. Agnes' Lighthouse, in the Scilly Islands, and northwards to North Rona Island, off the north-west coast of Scotland, with the sanction of Lieut.-Col. Hall, his successor as superintendent of the survey. When all these arcs have been compared together, it may well be expected that a more accurate knowledge of the actual figure of the earth, within this portion of the northern hemisphere, will be acquired than could have been reasonably expected, and many glimpses obtained of the position and magnitude of those masses of igneous rocks which have been agents in uplifting and fracturing the stony crust of the earth.

When the triangulation had been carried into Scotland, it required all the energies of Captain Colby to meet the demands upon him, as he had not only to conduct the observations in the field, but also to watch and regulate the proceedings of the interior survey. In 1813, Captain Colby, assisted by Mr. Gardner, visited two principal stations in Scotland, and two more were visited by Mr. Gardner; in 1814, Captain Colby observed from ten stations, and Mr. Gardner from four more, and when the preliminary labour of examining a country and fixing upon stations has been explained, the amount of activity and perseverance called forth by a "season on the hills" will be understood and appreciated. In 1815, Captain Colby appears to have been obliged to attend much to official business at the Ordnance Map Office in the Tower, and to the superintendence of the topographical survey in England and Wales, in consequence of which the actual observations with the great instrument in Scotland were, during that year, principally made by Mr. Gardner,—though, aided by that activity and energy which seemed to bestow upon him the power of multiplying himself, he did not neglect to watch over his favourite work, and hence in a letter of this year he thus writes, —"Our theodolite sustained no injury in the very violent storm which destroyed the tents, and put an early period to our summer's operations. But the weather, during the whole of the season, was so unusually unfavourable in the west of Scotland, that I was quite disappointed as to the quantity of work which from a comparison with other summers I had expected to be able to perform. We commenced on Bengairn Hill, near Kirkcudbright, and concluded on the Black Carrick Hill, near Ayr; thus completing the connection between Cumberland, the Isle of Man, part of the coast of Ireland, and the south-west of Scotland, as far as Ayr. The survey is now advanced to that state in which the determination of the positions of the observatories of Edinburgh and Glasgow became the next object for consideration. I find that both are in sight of such stations as will form well-shaped triangles with them, and at the same time that Ben-Lomond to the north and the Dunrick hill to the south, will each give two sides and an included angle to compute their distance from each other. If we may admit the principle of two sides and an included angle to ascertain the converging of meridians, Ben Lomond being also seen from the Island of Isla, a large extent may be measured in that way perpendicular to the meridian." So that it may be safely said, that though his hand had not always regulated the movements of the instrument, his spirit had planned and directed the operations on which it was engaged.

From a copy in his own handwriting of this remarkable letter, addressed, apparently either to Prof. Playfair or Prof. Leslie, it is right to extract those passages which mark the high value which was then set upon his opinion, as well as the enlightened view he always took of scientific subjects. He had been consulted respecting the Edinburgh observatory, and he replies, "Having had a good deal of conversation with Mr. Wm. Playfair about the Edinburgh observatory, and seen the plans for the building, I was desirous to consult you as to what is the best means for raising a fund to defray the expenses of the building and the annual salary of the observer. Surely there is no country on earth to which astronomical science is of so much consequence as it is to Great Britain; and the progress which the mathematics have made, and are making, at Edinburgh, points it out as one of several fitting places in the island for the cultivation of astronomy. Add to this, the Calton Hill presents an admirable situation for the erection of a scientific observatory. It is near enough to the city to be under the continual superintendence of the professors of the university and other learned men, and at the same time so far elevated above it as to prevent the smoke from interfering with the observations. The foundation being a rock, is also no small advantage. In short, so numerous and cogent are the reasons which may be given in favour of the astronomical institution of Edinburgh, that I can hardly think the Government would withhold its aid if they were fairly set forth for their consideration. The annual sum required for its support would be so small in comparison of the good which it might certainly be expected to produce, that the most rigid political economist, if acquainted with the nature of the subject, must give his assent. No sciences or arts can remain in the same state for any length of time; they must either be improving or falling to decay. The experience of the world has taught us that they fall much faster than they rise. Without due encouragement astronomical science may gradually decline; and it is of so much importance to the honour and the interest of our nation to support it, that I scarce think such a memorial as would emanate from your pen could prove altogether ineffectual." Since the time when Captain Colby thus forcibly expressed his opinions on this interesting subject, the multiplication of working observatories, public and private, at home and abroad, and the many important discoveries which have been the result of such continuous and wide-spread observations, have at once, as it were, responded to his appeal, and justified its wisdom.

In the earlier period of his connection with the Survey, Captain Colby had usually established his residence, when not in the field, as near as possible to that of General Mudge, but his immediate presence at head-quarters became desirable when the work of reducing the actual surveys to the scale required for engraving, which necessarily increased proportionately to the number of surveyors employed in the field, had so far augmented as to render constant supervision indispensable, and he had, therefore, taken possession of apartments at the Drawing Room, or Ordnance Map Office, at the Tower. Surveyors belonging to the corps of Surveyors and Draughtsmen were now employed in various parts of the country, by permission of the Chief Engineer (Inspector-General of Fortifications), who was the official head of the corps, and they received, besides their military pay as warrant officers, 32*s.* 6*d.* per square mile for all the work they surveyed and plotted on a scale of two inches to the mile. These plots were reduced at the Map Office to plans on a scale of one inch to a mile, and traces from them prepared for the use of the engravers. It will be readily believed that the superintendence of all these operations, simultaneously proceeding at so many different places, some in the Map Office, some at various parts in the country, combined with the personal direction of the triangulation in Scotland, was enough to overpower the mental energies and the physical powers even of a Colby; and in 1816, therefore, at the recommendation of General Mudge, his son, Lieutenant Richard Mudge, R.E. (now Lieutenant-Colonel Mudge), was attached to the survey, and stationed in the country, as nearly as possible in the centre of the surveying parties, of which he had the immediate superintendence from that period for several years. This partial relief enabled Captain Colby to visit nine stations in Scotland during the year 1816, without the harassing distraction of mind which had hitherto attended the complicated charge of such distant works. In 1817, also, Captain Colby was for a long time in Scotland, and in that year measured, with the assistance of Mr. Gardner, the single base line of that kingdom, on Belhelvie Sands, near Aberdeen. The measurement of this base occupied from May 5th to June 6th, and Ramsden's steel chain was again the instrument used. Its length, when compared with the unit Ordnance standard bar O, is found to be 26516·66 feet, and the length, as deduced from the Lough Foyle base, is 26518·99 feet, showing a difference of about $2\frac{3}{10}$ in five miles. Some of the old bases have afforded a better and some a worse comparison than the above; for example—

| | |
|---|---|
| Hounslow Heath base, with glass rods, when reduced to the Ordnance standard, 1784 | 27405·06 |
| Ditto, with steel chain, 1791 | 27405·38 |
| Deduced by computation from Lough Foyle base | 27405·83 |

A result which may be considered unparalleled in geodesy, when the extent of the triangulation intervening between the two bases is considered.

| | |
|---|---|
| Salisbury Plain, by steel chains, 1794 | 36575·64 |
| By Colby's compensation bars, in 1849 | 36577·95 |
| Computed from Lough Foyle base | 36577·34 |

A result equally beautiful and illustrative of the general excellence of the instruments and work of the British triangulation.

| | |
|---|---|
| Misterton Carr, steel chains, 1801 | 26343·72 |
| Computed from Lough Foyle | 26350·76 |

The difference here is considerable, and has been partly accounted for by the unfavourable ground; but it must be remembered that the comparison before quoted between this base as measured, and its length as deduced from other bases, was not so unfavourable as to render this explanation quite satisfactory—

| | |
|---|---|
| Rhyddlan Marsh, Steel chains, in 1806 | 24515·2 |
| Computed from Lough Foyle | 24518·2 |

It is impossible not to see in these facts proofs at once of the great care applied to the measurement of the first bases, of the precision attainable by General Colby's compensation bars, and even by the steel chains under due restriction, and of the superiority of the triangulation by which they have been linked together. This high character, indeed, was always maintained by the British survey, even when the results, which have been pointed out, were the subject of so much discussion. M. Arago, when resuming, in a letter to Colonel Mudge, the subject of a connexion between the English, French, and Spanish measurements, says: "If this proposition should appear reasonable, it will afford me the further advantage of manifesting to you the confidence with which your operations have inspired those scientific men who are best able to appreciate them;" and Schumacher was so satisfied of the excellency of Ramsden's sector, that on his recommendation the King of Denmark requested the loan of it for the celestial observations of the Danish arc: "The illustrious president of the Royal Society has informed me that you (Colonel Mudge) are about to re-examine your celestial arc in the following summer, and that you approve of lending the sector to the King for the determination, also, of our celestial arc. May I beg you to inform me whether it will be necessary that I should apply to any other person than to you, who have used the instrument in the beautiful work you have just terminated." It is remarkable that in this letter (1816) Schumacher anticipates what has now been satisfactorily proved, namely, that a considerable deflection of the plumb-line had occurred at Dunnose: "I have not seen," he says, "what Dr. Gregory has published on the subject, and I know only your observations by what has been printed in the 'Philosophical Transactions,' but from that I feel assured that the new observations will only confirm the old. You, who know the ground, are best able to judge where local attractions are most probable; but, on my part, I must confess that I should suspect them rather *at Dunnose than at Arbury Hill.* And further, it seems to me that in any hypothesis it would be very difficult to establish a perfectly regular figure for the earth. Such an hypothesis is, indeed, the least probable of any; and we ought not, therefore, to condemn observations because they tend to destroy an hypothesis which has so many chances against it."

It may be here observed that the instruments used on the Continent and in England for determining zenith distances were very different; as the sector, improved by Ramsden (several had been made of very large dimensions, by Sisson, at a very early date—for example, that of Pisa, 1765, and Dr. Maskelyne's, both of ten feet radius), continued the favourite instrument with the English geodesists, whilst the repeating circle of Borda had been generally adopted by French and other continental observers. The principle of the repeating circle, so far as the mere reading of the limb of the instrument is concerned, is very beautiful, as it reduces the separate readings of a number of observations to two, namely, one at the commencement and the other at the end of a repeated angle, equivalent, in magnitude, to the sum of the total number of separate or individual readings, so that the error is reduced to an inappreciable quantity by being divided amongst so many parts of the multiple, or repeated angle; and it was therefore supposed possible to attain the utmost precision with very small repeating circles. But it must be manifest that whilst correcting the errors in reading of the divisions of the instrument, nothing has been done towards correcting the errors of observation or of bisection of the object observed, consequent on the use of small instruments; and further, that the difficulty of guarding against any slight movements of the concentric circles during observation by any system of clamping hitherto devised has not been remedied. Schumacher, whilst admitting that the repeating circles of Reichenbach far surpass those of the French artists, still asserts, "that it is impossible to rely upon any permanency in the constant error when the limb of the instrument is placed in a vertical direction," and adds, that he "should not consider his work well finished, if the amplitude of the arc were to depend only on observations made with an instrument, the peculiarities of which were as yet insufficiently known, and not on those made with an excellent sector." It will be readily, therefore, supposed that any opportunity of bringing these two instruments into direct comparison with each other would be hailed with satisfaction by astronomers, and something in that respect was anticipated from the co-operation of the French and English geodesists, during the year 1817.

In October, 1816, M. Arago, on the part of La Place, communicated to Colonel Mudge the wish of that illustrious philosopher that the latitude of Yarmouth should be determined by the sector, in order to terminate at that point the French arc. "He sees," says Arago, "in the arc extending from Formentara to Yarmouth the means of determining with great precision the value of a degree of latitude at the 45th degree. The situation of the two extreme stations almost on the same meridian would render the result entirely independent of any flattening of the parallel, if such really exist. This operation, indeed—equally remarkable for its extent, for its object, and for its precision — would further have the more precious advantage of belonging equally to England as to France, and would become one day perhaps the basis of a uniform system of weights and measures." On the 4th of July, 1817, La Place himself writes: "Thanking you for your very kind reception of my proposition to terminate the French arc at Yarmouth, I must, at the same time, express my assent to your opinion that as it is now intended to extend the British arc to the Shetland Islands, Yarmouth may be replaced by the terminal station in these islands, even though Formentara is about 1½ degree in longitude to the eastward of it. The difference in latitude between the extreme points will then be about 22 degrees, and as their difference in longitude is so very small, the geodesical operations of France and England may be referred to this arc without fear of any sensible error. It is therefore most important to determine the latitude of the station selected in Shetland with the utmost precision, and for that purpose to determine the zenith distances of as many as possible of the stars, which may be observed for altitude at Greenwich and Paris. My friend M. Biot will not fail, I am sure, to use every care in determining the length of the pendulum at that station. We are about to measure a great arc of the parallel between Strasbourg and Brest, and we shall then have all the data required for a correct knowledge of the portion of the earth on which we live—and surely, thus to study the earth is far better than to devastate it by conquests, however brilliant and glorious they may appear. I am delighted to hear that you propose to send the great sector to Brest, and I think that M. Arago will join you there, and assist in the determination of the latitude, either by observing with the sector, or by simultaneously observing with a good repeating circle; and as the singularity of an increase in the degrees from the pole to the equator, as shown by your observations, has excited so much discussion, I would suggest that it might be advisable that you should afterwards repeat with Messrs. Arago and Biot, the zenith observations for latitude at Dunnose." With a view then to this co-operation between the French and English geodesists, so strongly advocated by La Place, and supported by the French Institute and Bureau de Longitude, M. Biot came over alone as a commissioner, on the part of the French, his colleague M. Arago being unfortunately retained in France by other business. The special object of this visit was thus stated by M. Biot himself who, after having expressed his opinion that the French arc, when compared with the independent measurements of Svanberg and Lambton, was specially entitled to become the fundamental type of a system of measures, observes: "Since the rebellion of 1745, the English government has felt the advantage of a detailed map of the three kingdoms to serve as the basis of works of improvement in peace and of works of defence in war. The English triangulation commenced by General Roy, and continued by Colonel Mudge, has already been carried from the south of England to the north of Scotland, so as to embrace several degrees of a terrestrial meridian, measured with excellent instruments. It was natural to wish that this arc should be joined to that of France, but the geographical position of England being a little to the west of our arc, it was feared that if all the terrestrial meridians were not similar the difference of longitude might affect the results deduced from such a junction. The Bureau de Longitude, therefore, wished that the pendulum apparatus which had been used in Spain and France should be also applied to similar trials at the principal stations of the English arc, as measures deduced from the pendulum are much less affected by small irregularities in the figure of the earth than are measured degrees." M. Biot subsequently adds: "When we had finished our experiments [at Leith] we were to have gone to the Orkneys to repeat them there, as the terminal station of the English arc, but Colonel Mudge, always anxious to render his operations as complete as possible, considered that it would be possible to connect the Shetland Islands with the Orkneys, by a triangulation, embracing the intermediate islets or rocks of Faira and Foula—a plan which, whilst it extended the arc about two degrees to the north also had the great advantage of bringing the English meridional arc two degrees more to the east, or almost in the prolongation of the meridian of Formentara." From what has been said, however, in a preceding page, it is manifest that M. Biot was in error in supposing that the design of terminating the English arc in the Shetland Islands was a sudden and after thought partly adopted, as it were, in reference to the French arc; as it has been shown, that Captain Colby had long before considered it a matter of course that the arc should be co-extensive with the triangulation, and therefore be terminated at the Shetland Islands; and that Colonel Mudge had finally adopted the same opinion there is not the slightest reason for doubting. The proposition of the French Board of Longitude was warmly received, and in every way encouraged and promoted both by the government, and by the scientific men of England. Biot arrived at Dover in May (1817), bringing with him his pendulum apparatus, a repeating circle by Fortin, an astronomical clock and chronometers by Bréguet, and, having been spared all the vexations of the Custom House, proceeded at once to London, and thence, accompanied by Colonel Mudge, to Edinburgh. Here he found in Colonel Sir Howard Elphinstone, Commanding Royal Engineer, a most valuable and active assistant, as he at once gave the necessary directions for forming, in the most solid manner, the supports for the pendulum apparatus, and for putting up the observatory in Leith fort: M. Biot expresses, indeed, his gratitude to that distinguished officer, in the very warmest terms. It had been the intention of Colonel Mudge to assist in M. Biot's observations, but his health soon failing him he was obliged to return to Woolwich, and his place was supplied by his son, Captain Richard Mudge, who was for the purpose called away from the Belhelvie base operations, in which he was then assisting Captain Colby. Biot speaks of him as "a young officer full of zeal, with whom he effectually completed his observations."

The observations finished, Biot, accompanied by Captain Mudge, proceeded to Aberdeen, there to embark for the Shetland Islands; and during his short sojourn at that city, where "he experienced the most marked hospitality," Biot must have first become personally acquainted with Captain Colby, and it is greatly to be regretted that this intimacy did not ripen into friendship, but, on the contrary, ended in a mutual distrust and dislike. The cause of an estrangement between two men, meeting for the express purpose of co-operation in a great scientific work, can scarcely be satisfactorily explained at this distance of time; but a reasonable conjecture may at least be formed of some of the springs of bitterness connected with it. Lieut.-Colonel Richard Mudge, who well remembers this interesting period of his life, emphatically declares, that had the ice once been melted between Biot and Colby, they would have mutually valued and respected each other; but it was fated that an eternal frost should separate them. Biot, Colonel Mudge thinks, was vexed at not being asked to take part personally in the observations of the British geodesists, whilst they appeared to ascribe to him injurious strictures on their proceedings, published in the "Caledonian Mercury." This latter charge Biot most solemnly denied, declaring that he had neither connexion with the offensive article nor knowledge of its author; and yet even Colonel Mudge seems to have clung to the belief that he had written it. But in addition to these petty causes for distrust and jealousy, it may be feared that the presence of Dr. Gregory did not contribute to harmony. That able writer, then Professor of Mathematics to the Royal Military Academy, had, with the sanction of the Master-General of the Ordnance, been invited by

Colonel Mudge to join him in Scotland; and though no one could doubt the propriety and advantage of obtaining the assistance of his great talents at such a memorable epoch of the survey, there is nothing unreasonable in supposing that a person of the peculiar and warm religious feelings of Dr. Gregory was not likely to enter upon very cordial intercourse with the French philosopher, at a time when it was so customary to connect with that name, as a necessary adjunct, the notion of an atheist. Certain it is that Dr. Gregory attached himself to Captain Colby; and that whilst the latter disliked and distrusted Biot, he, Biot, detested Dr. Gregory: and indeed it may be added, as another probable ground of this enmity, that Don Rodriguez, who had been so severely attacked by Dr. Gregory, in reply to his criticisms on the English arcal measurement, had been the associate and friend of Biot in the triangulation of France and Spain. With all these elements of disagreement unhappily existing amongst them, the little party embarked in the Investigator surveying ship, commanded by Captain George Thomas; and the bitter feelings of Biot may be readily recognised in the fact that he cautiously avoided any mention of the name of Captain Colby in the account of his subsequent proceedings, merely observing: "When this great project, the extension of the arc to Shetland, had been resolved upon, it absorbed all our thoughts; and as the delicate health of Colonel Mudge did not enable him to engage in it, he intrusted its execution to one of the officers serving under him." That one officer was Captain Colby, who had for so many years personally conducted the triangulation in Scotland, and who had so long kept his eye steadily on the rocks of the ancient Thule, as the fitting termination of the British arc. Great, indeed, must have been the irritation, which could have prompted Biot thus to leave him unnamed, and even unnoticed, except as an ordinary subordinate: and under its influence it was to be expected that every trifling incident would assume an undue importance, as was the case on landing on the principal island, or "mainland," of Shetland, when Captain Colby and Mr. Gardner proceeded directly across the island towards Lerwick, leaving M. Biot and Captain Richard Mudge to follow by another route and by themselves—an arrangement which appeared to the French philosopher a deliberate slight; though, had he become more fully acquainted with his antagonistic colleague, he would have known that it was his invariable rule to take advantage of every such opportunity of seeing a country by leaving the more ordinary course, and crossing in a direct line every mountain-peak which might fall in his way.

An evil, however, much greater than mere personal pique, occurred, on the arrival of the party at Unst, and that was no less than the disruption of the plan of combined observations—Captain Colby observing with the sector in the small island of Balta, and Biot swinging his pendulum, and observing with his repeating circle at Unst. Neither party can be fully acquitted of some share in the blame of this result; for though, without doubt, Captain Colby was the best judge of the most fitting site for the sector—considered also as a station of the triangulation—courtesy to an eminent foreigner, expressly come over to co-operate in a common design, should have suggested that a consultation with Biot on the best position for both their observations was very reasonable and proper. And yet no want of such courtesy was sufficient justification in itself for the adoption of a plan which has at least diminished the value of a comparison between the observations of the sector, of the repeating circle, and of Borda's pendulum, which would have been made perfect by a unity both of time and place. The propriety of the selection of Balta has been confirmed by subsequent observations, and M. Biot does not advance any sound objection to it in his published statement. After vividly contrasting, as two regions of the terrestrial arc most widely opposed to each other in position and physical characters, the smiling garden-like fields of Valencia, its orange and citron-groves, its perfumed air and historic reminiscences, with the rocky coasts, the craggy mountains, the damp, desolate, and bare surface, and the inclement climate, of the Shetland Islands, strewed over, indeed, with moss-encrusted stones, but neither adorned nor clothed by tree, shrub, or herbage, he states that: "On embarking in Scotland, it had been expected that we should have established ourselves at Lerwick, where Fort Charlotte would have afforded a most favourable site for all our operations, but that we had been tempted onwards to the smaller island of Unst, as being at once half a degree more northwards, and somewhat nearer the meridian of Formentara. Arrived at Unst, we eagerly traversed the island, and met only the cabins of fishermen, with here and there the house of a farmer too small to receive the large English instruments; but fortunately the English Commission was provided with tents. At first it was proposed to establish the sector on the highest and most northern mountain of the island; but the difficulty of carrying up so great an instrument on men's shoulders—the only possible mode of conveyance—rendered it necessary to abandon that project, and the island of Balta was selected in preference. This little island is situated at the entrance of the principal bay of Unst, and serving as a breakwater against the sea, forms an excellent harbour, in which our ship was securely anchored, whilst the instruments and stores were landed in safety. At first I concurred in this arrangement, but on reconsideration, I thought of the furious storms to which the new station was exposed, its extreme humidity, the distance from any house, and the many difficulties in the way of forming a sufficiently solid foundation for pendulum experiments; and I feared that by persevering in adhering to it, I should endanger the success of my operations. In consequence, Captain Mudge and myself returned to Unst, and availed ourselves of the hospitality most liberally offered by Mr. Edmonston, the brother of Dr. Edmonston of Lerwick, who had himself shown us so many kindnesses, and given us letters of introduction to his brother. The pendulum apparatus was established in a large empty sheep-house, with massive walls, and the observatory for the repeating circle was erected in the garden; but it was not till the 2nd of August that by the united labours of the crew of the Investigator the large stones required for a foundation had been dragged to the spot, and the work of observation commenced." In all this there is not a word of complaint against the selection of Balta as the most fitting station for the sector or for the great theodolite; and there seems scarcely sufficient explanation given why more difficulty should have been experienced in establishing a fitting site for the pendulum and repeating circle, than for an instrument of the large size and delicacy of construction of Ramsden's sector. The result was a source of much mortification to Colonel Mudge, who thus writes (August 12th, 1817): "I had the most perfect reliance on your judgment and good disposition towards me, and asserted publicly that though you were silent, I was positively certain that everything you did was right, and that I would stand by the consequences. I have now a full and comprehensive view of the question as it stands between us, and I *approve of everything* you have done. I think it appears pretty plainly that the sectorial and pendulum operations are anything but combined; as from the map I perceive that Unst is one island and Balta another; and I can see no reason for supposing that M. Biot's experiments will last half as long as your observations, the rate of his clock being soon got, and the transit of one pendulum to the place of another is had, though the clouds conceal the sun, or hide stars. But the state of the case, as it affects your operations, is another matter, and affords serious matter for consideration. The season is far advanced, even for this climate, but for Shetland, still further, and offers the assurance that your operations will not be concluded without your having had many an ample taste of Shetland weather. That a great deal will be left undone in the way of observation with the theodolite, I naturally conclude will prove to be the case; but I do most earnestly hope that the observations with the sector will be finished by you, now that the instrument is up, with the same accuracy and excellence as at Cowhithe Hill and Largo Law. I hope you will contrive, somehow or other, to compare the rate of your clock with M. Biot's, the reasons for which are obvious; your watch is a most excellent one, and may do very well, to convey the time from one to the other, and it is of prime importance that this should be done. I have very great confidence in our clock, and the stability of its pendulum. I am fully aware, however, of the advantages which attend the French pendulum, and I know also where its disadvantages lie; but the whole operation connected with the pendulum of Borda seems likely to give the most satisfactory result. One great disadvantage attending your removal from M. Biot is that a comparison cannot be made between the results of observations made for determining the zenith distances of the stars with the sector and circle of repetition: this is a very great misfortune.* I most particularly dwelt upon the necessity and advantage of this with M. Biot; and I am sure that very severe and heavy reflections will by and by be made on the ground of this not being done. It was the only opportunity we could have had in this country of fairly trying the question, which seems as if fate had decided on that matter being determined at Dunkirk. I had been in hopes to have seen the operations finished so early as to admit of the sector having been sent to Dunkirk this year, and I had obtained Lord Mulgrave's leave to take it there; but I see now there is little chance of its seeing the other side of the water till the spring. I should like to hear from you an account of the stations (if any) which may have been visited in Shetland for carrying on the distances from the south to Balta; and what you may have done in the way of observing at Faira and Foula, but perhaps these have not been visited; and I may perhaps think we shall have done not a little if the sectorial operations be completed, and a fair knowledge obtained of the manner of finishing the survey in the north with the greatest effect and advantage to the general question. As to myself, I do not wish to exhibit the folly of useless complaint; but as the queen who gave up Calais said that 'that word would be found written on her heart,' I may say that Shetland will be written on mine, for I have never ceased to deplore, with the keenest recollection, the happiness that I thought before me nipped in the bud, and I sent home, as it were, invalided." On the 1st of August M. Biot and Captain Richard Mudge made the first experiment with the pendulum; and on the 17th they had completed eight of these experiments, and 270 observations for latitude. The health of Captain Mudge now began to give way, and he was at length persuaded by Biot to quit the island in a whale-ship,

* The Latitude of Unst by Biot is 60° 45′ 25″. The Latitude of Balta by the sector, 60° 45′ 1″·6, and adding to this 26″·9, the geodetic difference between the two sites, the latitude of Unst is 60° 45′ 28″·5, or 3″·5 more than Biot's determination.

and return to a less severe climate. Biot being thus left alone, trained a young carpenter of Unst, who, like the Scotch in general, had been well instructed in reading, writing, and arithmetic, to read and note down the indications of the level of his repeating circle, as without such assistance he could not have continued his observations. The zeal and scrupulous accuracy of this young mechanic, which Biot took care, in the first instance, to verify by proper checks, were warmly applauded by Biot, who says, "With this assistance, at once timely and trustworthy, I succeeded in two months in obtaining thirty-six series of pendulum observations, each extending over five or six hours, 1400 observations for latitude in fifty-five series, taken both to the north and south of the zenith, and about 1200 observations of altitudes of the sun and stars, for the determination of the rate of my clock; and from all this it may be conceived that I could do little but observe. In truth, I was obliged to restrict myself in calculation to what was necessary to satisfy me of the satisfactory progress of my observations, and to reserve the final calculation till my return to France; and it was well I did so, as, after all the time bestowed upon them, they are not yet entirely completed."

When Biot had terminated his observations at Unst, he wrote to Colonel Mudge, requesting that the Master General would give him official authority to take part in the sectorial observations at Balta, on the *perpetuation* of the principle which had brought him into England, but to this strange request, Colonel Mudge replied, "he was sure that Captain Colby would be happy to coalesce with him for the joint advantage of the work, and that he was a man so sound in understanding and every honourable principle, that M. Biot might safely throw himself upon him, persuaded that he would meet him on the same liberal principle that he, Colonel Mudge, should do." Biot did not, however, remain longer, but taking advantage of a small country smack, trading to Berwick, returned southward before the "Investigator" could be despatched to remove him. Making every allowance for irritated feelings, and even assuming that more courtesy should have been shown to him, it is evident, from his own statement, that Captain Colby could not have prevented the unlucky separation by any possible change of his own arrangements. Had he encamped on the highest northern peak of Unst the difficulties in the way of M. Biot's arrangements would certainly have been greater than at Balta, and it was manifestly impossible to fix the trigonometrical station in the garden of Mr. Edmonston's house. Biot dwells indeed with delight on his residence at Unst, and attributes to his selection of that station the intimate knowledge he obtained of the warm-hearted hospitality, and other sterling qualities, of its inhabitants;—and says, "If I had remained on the rocks of Balta I should, without doubt, have gone away with all the prejudices of a foreigner; and have dwelt only on the sadness of the islands, the poverty of their soil, and the inclemency of their climate." Such indeed might have been the case, but he would have then succeeded in all the great objects of his visit by not only completing his pendulum experiments, but also by bringing into direct comparison the two rival systems of observation. Voluntarily he withdrew his own observatory and operations from the notice of the English party; and it seemed scarcely reasonable that he should then have sought to take part in their work. Steadily, however, they adhered to their rock; and accustomed to brave the fury of the storm, and to make themselves at home on the most rugged and cheerless ground, they patiently pursued their course until they had successfully completed their observations. Biot's experiments with Borda's pendulum, consisting of a platinum ball suspended by a wire from a knife edge, were subsequently confirmed by those of Captain Kater with the bar or invariable pendulum,* and were conformable in their results to the received or Newtonian theory of the earth's figure; but from a want of co-operation in the two sets of observers, they have not thrown any light on the physical or other causes which have modified the geodesical evidence of the English arcs. In 1817, Sir W. Congreve suggested to Colonel Mudge the use of instantaneous signals for the determination of differences of longitude, as noted in the following letter to Captain Colby: "I send you a letter that I have received from Sir William Congreve. It appears to me that he is providing what may be of great service to us, so that if you will come down on Monday with Mr. Gardner, we will, at night, attend Sir W. Congreve's together. If Sir W. Congreve can continue to exhibit by explosion combustible matter of great brilliancy, capable of being seen at 40 or 50 miles with ease, he will afford the means of finding the difference of longitude between two places much nearer than has ever yet been done by means of time. I wish you would write to Mr. Wolcott, and tell him to look out from Hampstead toward Woolwich from eight until nine, and somewhat after, on Monday next." The first use of artificial signals was, however, of more remote date, as Picard employed them in 1671 to determine the difference of longitude between the tower of the observatory of Copenhagen and the ruins of the far-famed observatory of Tycho-Brahe, in the Island of Huen. In this case, the signal was a fire lighted on the tower of Copenhagen, which was alternately concealed and exposed to view, the times of appearance and disappearance being carefully noted at the two stations; and as the distance was only six leagues, the plan answered tolerably well. At a distance, however, of thirteen leagues a fire of three feet diameter would not appear to the eye larger than a star of the third magnitude, so that with great distances the difficulty of suddenly masking the light of still greater fires would become almost insurmountable. In 1735, it was proposed by Delisle and La Condamine to use the flash from a gun, or even from a heap of exploded powder, and La Condamine proposed a change in the ingredients of ordinary gunpowder, so as to produce a more vivid light. In 1738, the French Academicians found that the light obtained by the explosion of six pounds of powder was distinctly visible at the distance of forty leagues. M. Cassini (third of the name), about the same time, observed that the flash of a 24-pounder, fired on the jetty near the lighthouse of Sete, was seen at Montpellier, although the mountain of St. Bauzel is 780 feet high, was directly in the line between the two places. Towards the end of 1739, Cassini and the Abbé La Caille determined in this manner the difference of longitude, 1° 53′ 19″, between the Hermitage of St. Clair near Sete, and Mount St. Victoire near Aix, the signals by the explosion, evening and morning, of charges of ten pounds, each, of gunpowder, being made on the flat roof of the Church of Saintes-Maries, near the lesser mouth of the Rhone. In 1811, Baron Zach, from whose correspondence these details have been extracted, repeated this observation, but expended in the signals only four pounds of powder, instead of ten pounds per signal, finding

* In this compound pendulum knife-edges are fixed transversely near the two ends of a flat bar, and when the number of vibrations is the same, on whichever of these edges the bar is made to vibrate as an axis, or the centres of suspension and oscillation are reciprocal, the distance between the two knife edges is the length of the corresponding simple pendulum. This coincidence is obtained by trial, the bar being supplied with a moveable weight, which can be adjusted so as to alter the position of the centre of gravity.

that signals were more instantaneous from the explosion of small than of larger charges. Baron Zach also used this method in 1802, in the survey of Thuringia, and thus noticed that a flash from a hill was seen, as a coruscation of light, fifty-five leagues, though the curvature of the earth concealed the hill itself. By the French, Italian, and Germans, this method has been subsequently used extensively, as for example in 1822, when the differences of longitude of the observatories of Vienna, Buda, and Munich, were determined, under the direction of Professor Littrow. The signals were made by the explosion of charges of half a pound of powder suspended in a horn to a post six feet high, and fired by a common port fire. The arc of longitude between the observatories of Buda and Munich is seven and a half degrees, and the operation combined the use of two subsidiary stations, four signals (? three), and the two astronomical clocks at the observatories; and Baron Zach states that the arc of longitude between Buda and Paris could have been determined by four stations, eight signals (? six), and three clocks. Before this, 1804, Baron Zach had exploded charges of six ounces of powder on the Brocken, which were seen on the Keulenberg, at the distance of 151 miles.

Common rockets were tried from Greenwich Observatory in 1775, but not being visible for more than six or eight miles, they are useless for such purposes. The Congreve rockets, however, more especially those improved by Captain Schumacher, a Danish officer, entrusted by the King of Denmark with his rocket department, were found to answer much better, as it was announced in the Danish papers, in 1819, that rockets fired as signals on the small island of Heelm, on the Categat, had been observed with a telescope by Captain Schumacher's brother, the celebrated astronomer at Copenhagen, a distance of twenty leagues.

Baron Zach states (1822) that Baron D'Augustin, a colonel of the Austrian Artillery, had invented rockets which were capable of ascending to the height of nearly 11,000 feet, or more than two miles; but that it was difficult to follow them in their ascent to the point of explosion with powerful telescopes of a small field of view.

It does not appear that Sir W. Congreve's experiment led to any immediate application of fire signals to the purposes of the survey, although the subject was frequently discussed by General Colby at a later period, and he always anticipated the use of the Drummond's Light, in determining the differences of longitude of important stations, distant from each other, such as the observatories of Greenwich and Dublin. The French have subsequently used rockets, though with only partial success, in the great arc perpendicular to the meridian, between Brest and Strasbourg, before referred to, and the English and French, in determining the difference of longitude between Greenwich and Paris, as described by Sir John Herschel, in "The Philosophical Transactions for 1826." In 1839, the Rev. Dr. Romney Robinson, the well-known astronomer of the Armagh Observatory, determined in this manner the difference of longitude of the observatories of Armagh and Dublin, the rockets having been fired from the top of Slieve Gullion, a high mountain near Newry, and eighteen miles from Armagh. This mountain is 1893 feet above the sea level, and though visible at Dublin fifty-seven miles from it, is cut off from Armagh by an intervening ridge, so that the rockets were required to ascend more than 800 feet in order to be visible on explosion. All the details of elevation, bearing of hills, angles of elevation or depression, effects of refraction necessary to facilitate the operation were furnished by Lieutenant Larcom (now Major Larcom, Under Secretary for

Ireland), from the documents of the Ordnance Survey; and it is not a little gratifying to those who have been connected with that great work, to read the disinterested testimony of so able a judge to its general excellence. "It is," he says, "really wonderful how completely every undulation of the ground has been registered in the survey. The altitudes sent to me, which must have been computed from the general sections, agree with observations in the most extraordinary way. A fact of another kind will show such persons as may not be acquainted with these things the precision of the Ordnance Survey. I set a telescope to the azimuth given for Slieve Gullion, and ascended the intervening hill with a theodolite, which I moved till, by signal from the observatory, it was in the line; then I took, with the theodolite, the angle between the telescope and the pile on the mountain top, where our rockets were to be fired; it proved 180° exactly, or the three points were in one right line."

It should be remembered that the survey thus commended had been planned and conducted by General Colby; and that the precision recorded had been attained by surveying and plotting on a scale of six inches to a mile—a consideration which ought not to be lost sight of in discussing the proper scales for other surveys, or in considering the comparative expense of this and other surveys. That a survey furnished with accurate levels, so numerous as to exhibit every undulation or swell of the surface, could be considered by any one useless for the preliminary examination of civil engineers, seems indeed scarcely reconcilable with the experience of Ireland, or with the ordinary deductions of reason. The Ordnance will doubtless be also gratified by the testimony which Dr. Robinson bears to the excellence of the rockets furnished from the Woolwich Arsenal—"The rockets," he observes, "were remarkably good; *not one* burst, which certainly is a singular contrast to the French rockets in Sir J. Herschel's and Colonel Bonne's operations. Their average rise, on the only evening I measured it, was 800 yards; they had, however, only four ounces of powder, but the part of the case which contained it weighed six ounces more, so that they actually carried a greater weight than the French." Much yet remains to be done to perfect the rocket as a military engine; but, even as the means of conveying signals at times and under circumstances when all other modes of telegraphing would be useless, their value should be deemed inestimable, when it is considered that a pound rocket will rise 1400 feet, a two-pound rocket will rise to that height and carry with it four ounces of bursting powder, and that Dr. Robinson succeeded in making some not heavier than the above, which carried four ounces of powder and rose to the height of 4500 feet.

The present opinion of British geodesists on the value of the signal system of determining differences of longitude is thus given by Captain Yolland, R. E., in his able and elaborate treatise on geodesy, which forms a second part of the third volume of the new mathematical course for the R. M. Academy: "The method by instantaneous signals consists in two observers, at A and B, accurately noting the correct time by the chronometers of the appearance or disappearance of the signal agreed on to be exhibited from some intermediate station, C, visible from both A and B. A careful person being stationed at the intermediate station C, with instructions to fire the gunpowder or signal rocket, or to cover or uncover the Drummond, Bengal, or blue light, at stated times, and to repeat the signal agreed on at certain intervals of time when the weather is favourable, so that the observers at A and B may be on the look-out at the proper time for the explosions, appearance or disappearance of the signal lights. A set of such observations will furnish a series of clock times for A and B, which may all be severally reduced to sidereal times from the observed times of transit of the selected stars, and the difference between such sidereal times is the resulting difference of longitude furnished by each particular observation. It is probable that the precision of the result, obtained by this method of determining the difference of longitude is greater than in that of any other process which has yet been followed."—To these remarks of Captain Yolland, a caution should, however, be added, that the determination of the *absolute times* at the two terminal stations should be effected in the most perfect manner, and, if possible, by fixed instruments; but as regards intermediate stations, intended merely to transmit the signals by observing the *relative difference* of time of their exhibition, a good watch showing seconds, and which keeps a tolerably steady rate, is sufficient, as the interval of time between the exhibition of the signals of the two adjacent stations intended to be observed by one person in succession, ought not to exceed a few minutes.

The field labours of the memorable season of 1817 having been closed, Captain Colby returned to the Tower of London, and soon afterwards his opinion on the subject of publishing the map of Lincolnshire was requested by Colonel Mudge —the publication of the maps having been suspended during the war.

His reply breathes the same liberal spirit which he always manifested in discussing any great public question—as may be judged from the following letter of February 2nd, 1818—" I have given what consideration I am able to the Lincolnshire survey, and I really can discover no good motive for rejecting the offer of the gentlemen of that county. It may, as Lord Mulgrave has justly observed in his letter, be proper to obtain some definite statement of their intentions; but to what more proper object can the survey be directed, in time of peace, than to aid the general improvement of the country : and how can that be done more effectually than in giving maps of these counties where the most beneficial changes are taking place? In the county of Lincoln, the spirit of adventurous agricultural improvement has been most eminently displayed. Individuals have improved their fortunes, and the nation has acquired additional resources from their efforts. New efforts are now making in the same county, and these efforts may be rendered more efficacious by the aid of the Ordnance map."—Captain Colby then examined in detail the several difficulties in the way of proceeding with the engraving of the Lincolnshire map, such as additional expense, interference with existing arrangements, &c., and having explained how easily they might all be overcome, proceeds thus: " Having shown separately the consequences of commencing the Lincolnshire survey, I come now to a summary of the whole. Lincolnshire, with the exception of a very small portion, would be comprised in five sheets. A sixth, which would probably contain a small portion of the Spurn Head, would be necessary to square the map. I should propose giving it to the proprietors in three parts, containing two sheets in each. The district which would form the first part is nearly all surveyed at present; and, consequently, that part might soon be put in the hands of the engraver. It would consist of a portion of Norfolk, the Wash, an interesting part of the county of Lincoln, and small bits of the adjacent counties. Thus the proprietors would not be long before they were possessed of an useful specimen of the work. The regular progress of the general survey from south to north need not be interrupted or essentially retarded, if a small additional sum were granted on account of the Lincolnshire map: but the small additional sums advanced to expedite the work would be more than compensated by the increased sale which would arise from bringing out the map at the time it is wanted, and with the good will of the proprietors of the county. Should they commence a survey at their own expense, the improvement of their property would be diminished, and when the ordnance map at length made its appearance it would find few purchasers. Their objects and ours would be alike defeated. I am sure I should be one of the last persons who would propose a deviation from the regular course of the survey; but in the present instance, there seems to me no difficulty in preserving that regular course, and at the same time meeting the wishes and furthering the interests of the Lincolnshire gentlemen." Before, however, this object could be attained, several years were destined to elapse, and it was not until Captain Colby had become the director of the survey on the death of General Mudge, that the Lincolnshire map was finally published. The principal cause of the delay was the necessity of a rigorous revision of much of the survey details; and on this occasion Captain Colby exhibited that calm and imperturbable firmness, which was a striking characteristic of his mind, as no external clamour for the map, nor reproaches for the delay, could shake his determination not to publish until its accuracy had been fully established. For this purpose he sent Lieut. Dawson (now Lieut.-Colonel Dawson), and Lieut. Robe (the late Lieut.-Colonel Robe, R. E.), into the country to go over it sheet by sheet, and it was only after this verification that it was published. The beauty and excellence of the map, and its improvement in the harmony, and proportionate accuracy of its shading, obtained for it unqualified approbation; and it was considered by the best judges as a great advance in topographical science and art.

The difficulties which had been experienced in the preparation of this map for the engravers, or rather in the examination and adjustment of old survey work, induced Captain Colby to devise a plan for promoting a more uniform system of sketching and drawing, as well as for ensuring greater accuracy in the survey itself; and for this purpose he proposed to place a certain number of assistants under Mr. Dawson, to be instructed by him in one uniform system of surveying, sketching, and drawing. These assistants were designed to become, in their turn, local superintendents, and thus to introduce everywhere efficient checks upon the accuracy of the work. Some of the gentlemen thus prepared did, for some time, good service on the survey; but General Colby was unable to carry out the scheme in its integrity, and a different system of organisation has subsequently superseded it.

In November, 1817, Messrs. Arago and Humboldt, accompanied by M. Biot, came to England with two pendulums, which were swung and observed at the Royal Observatory, Greenwich, in the presence of Mr. Pond, the Astronomer Royal, having been previously experimented upon at Paris. M. Biot writes on the 24th November to Colonel Mudge, "I must not delay further replying to your kind proposition, by saying that M. de Humboldt, M. Arago, and myself will be most happy to see the sector at your house at Woolwich, in anticipation of the gratification of using it with you at Dunkirk." In reference to the two first of these great men, Humboldt and Arago, Colonel Mudge, in notifying their arrival to Captain Colby, observes, "I do not perceive the slightest impression on their minds similar to that which animated the man when he wrote in the 'Caledonian Mercury.' Your report is quite the thing, and suits my purpose exactly, as well as being a sufficient proof of your consistency." And it may be here observed that the coolness between Biot and Captain Colby never extended to Arago, who, on the contrary, manifested towards him feelings of very strong regard. The project of taking the sector to Dunkirk, so anxiously looked forward to by both the French and English astronomers, was not carried into effect till late in 1818, as Captain Colby was actively engaged in Scotland from May 19 to September 17 of that year, having observed from nine mountain stations in that country during the interval. On September 1, Colonel Mudge wrote to Captain Colby, "The remainder of this letter must contain matters of official importance to us both, as you know the engagement under which I was made to place myself is now arriving towards fulfilment—I mean the Dunkirk expedition. I have received two letters from Biot, written with some anxiety upon this subject, which I had indeed anticipated by stating to him that on your return from Scotland we would both accompany the sector to France, at the same time telling him that it would be late in the season before we could effect that measure. Biot's reply was that it would perhaps be advisable to bring over the sector myself much sooner, as the observations were very simple, and might be made while you were going on with your operations in the North. To this letter I have replied with as much candour as I hope I have always shown on every occasion—that accuracy and truth have been always my aim—and that I will not vitiate that character by attempting that which I am not capable of performing. I have told him that with the knowledge and judgment upon the subject equal to what it ever has been in any former period of my life, I am now not so equal to the work of observation as yourself, and that I deem it a just tribute to give you the honour of making the observations at the south end of the arc, as well as the north, assured by so doing that the character of the whole work will be best preserved, and my own interests effectually served therewith. Now, I do say that though you have no reason whatever to be pleased with Biot—and God knows I have just as little—yet I trust you will see with me the actual necessity of our concluding the work of this year in France. I feel that by so doing I shall conclude my labours honourably, and I would be sorry after a life that has left me but little more to boast of than a desire to do right, that I should conclude it inconsistently." From this letter it is manifest that whilst Colonel Mudge anxiously desired that Captain Colby should conduct the observations at Dunkirk, from a conviction on his part that there was no other person equally skilled in the use of the sector, or equally able to maintain the credit of the British geodesists, Captain Colby would have readily relinquished the task to any other person, so strongly did he resent what he deemed the unjust conduct of M. Biot towards him.

An extract from a letter of M. Biot to Colonel Mudge, of the previous 2nd of December, will in some degree explain and in great measure justify the feeling of Captain Colby, as there is no doubt it had been communicated to him—"As to the affair of the pendulum, I have only heard of it from yourself, not having had any participation in the experiments made at the Island of Balta. As to the discrepancies which you mention, as occurring between the results obtained from experiment in that island, and theory, they cannot be deemed a secret, as other persons have spoken to me about them before I had myself breathed a syllable on the subject. Captain Kater has pointed out to me the cause to which you consider that this want of success should be ascribed; but if I rightly comprehend your meaning, I do not see how the knowledge of the cause, which has rendered the observations erroneous, can be made a reason for forming a favourable opinion of them. Further than this, I judge no one. I restrict myself to the duty of making my own observations with all the care I can bestow upon them, and I leave others to *conduct theirs as well as their knowledge will permit.* I have not come to this country to act the part of a critic, and I have no desire to mix myself up with literary quarrels." These remarks, which could only have referred to Captain Colby, were certainly neither very candid nor very friendly, and, combined with the effort to induce Colonel Mudge to undertake the sector observations at Dunkirk without the aid of his colleague, strongly marked the disinclination of M. Biot to co-operate with Captain Colby; whilst, on the other hand, Captain Colby had little confidence in the French observers, and was always disposed to contrast unfavourably the respective systems of the two countries; the French results being, as he supposed, occasionally *cooked* or *humoured,* to suit an object, whilst on the British survey it was laid down as an inflexible rule, that *all* observations should be recorded, and that *none* should be rejected, unless an entry of some cause of imperfection had been made at the time when they were taken. Notwithstanding, however, these personal dislikes, Colonel Mudge and Captain Colby proceeded to Dunkirk, and were there joined by MM. Arago and Biot, when the sector was put up in the arsenal. It is said that the French philosophers pronounced the sector "the finest instrument in the world;" but there is some doubt whether they really assisted in the observations, and it is certain that the desire of Colonel Mudge to bring the sector and repeating circle into direct comparison with each other, was not even gratified at Dunkirk, as such a comparison could only have been satisfactorily effected by a mutual interchange of the records of actual observations, before any corrections had been applied to them, and it does not appear that the French observations, in their original state, were communicated to the British observers, although a copy of the sector observations was transmitted to the French. In June, 1819, Schumacher writes thus to Baron Zach on the subject: "On my return from London, I hasten to inform you that Ramsden's sector has safely arrived, and that I am about to put it up at Lauenburg. Colonel Mudge has communicated to me the latitude of Dunkirk, as observed with this instrument, but the place of observation was not the same as that at which the French observations were made. It was agreed that the observations should be reciprocally exchanged between the two parties, and Major Mudge sent a copy of his as soon as taken, but up to the time of my departure from London the French observations had not been received. M. Delambre told me, at Paris, that the latitude obtained by Colonel Mudge, with the sector, was in perfect accordance with that which he had obtained;" but on this statement Baron Zach remarks, in a note, "Up to this time we have only reports, accounts, assertions as to this agreement, unsupported by any evidence or proof of their truth; we must therefore wait until the original observations have, as is customary in such cases, been published. Until then, no satisfactory judgment can be formed of this important work, on which the attention of all the learned men of the world has been fixed for twenty-five years." In December, 1819, Schumacher refers to his own observations with the sector, at Lauenburg, and mentions the visits he had received during their progress, from Gauss, Olbers, and Bessel. "To give," he says, "the greatest authenticity to these observations, and at the same time to testify to the English the gratitude we feel to them for the loan of the instrument, I send to General Mudge a copy, sheet by sheet, of my journal, the observations being written as taken by Wedgwood's double writer, so that the example sent is identical with that retained." And Baron Zach added a note to the effect that "General Mudge did the same at Dunkirk, as regards the

French astronomers, though he did not receive their observations in return, though they had been promised." These statements of Schumacher and Zach excited very great indignation on the part of the French, and called forth a report on the subject from Biot, which is thus referred to in a letter dated Altona, November 10th, from Schumacher to Captain Colby, then Director of the Survey, and written in terms of the warmest friendship:—"It is long ago since I heard anything of you, and you must know how agreeable every line from your hand must be to me. Can you spare a moment for one of your most sincere friends and admirers? You do somewhat wrong in depriving me of it. M. de Zach has published a confidential letter of mine, where I told him what I heard from the late General Mudge, that the French astronomers at Dunkirchen had not communicated their original observations to you, as it was agreed. It is certainly against the most common laws of honour to publish what you have of a friend for private communication; however, the thing is done, and MM. Biot and Arago are now in a violent dispute with Zach. They have not yet attacked me, but when they do, may I expect your testimony for the truth of the assertion? You would do me a particular favour if you could now bring the testimony of our worthy deceased friend, without acting against that which the French call *délicatesse.* The answer of the French is very artful. Zach had said (of his own accord) that you had *daily* communicated your observations. This point they take up, and their whole answer refers to the expression *daily.* 'It is not true,' they say, 'that an engagement was entered into by the English and French to exchange, day by day, their observations. It is equally untrue that General Mudge did communicate his daily. From the commencement of our union, and so long as it lasted, we freely offered to the English astronomers the use of our instruments, either separately or in conjunction with us; an offer, however, of which they did not avail themselves. On our part, we requested permission to observe with the great sector of Ramsden, and not only was it granted, but every necessary instruction for the use of that fine instrument given to us. They have communicated to us their registers, and supplied copies of a certain number of their observations: but this permission to use the instrument was not given, and this communication of the English observations was not made, until after we had communicated to General Mudge the latitude of our station, deduced from observations made with the repeating circle both to the south and to the north of the zenith.' Mark," continues Schumacher, "how artfully this is expressed. They do not say, *they observed* with Ramsden's sector, but every one who reads it will understand it in this manner; and I remember very well how our late friend, after having read, at a dinner at his house, where a large company was, the report of Biot, exclaimed, 'God bless me! they never touched the instrument!'"* In this statement Schumacher should not have said that Baron Zach made the assertion of a daily communication, *on his own accord,* as the meaning of Schumacher's words, "Major Mudge communicated his observations as soon as they were made," was precisely the same. Making, however, every allowance for wounded feelings, and remembering that the report of Biot was written as a justification, it may be distinctly gathered from its admissions that the English astronomers communicated not merely a part, but all their observations, for when they sent *their registers,* they manifestly commu-

* Lieut.-Col. Mudge confirms this statement that the French astronomers never availed themselves of the permission to observe with the sector though they had solicited it.

nicated the observations just as they were taken and recorded; they therefore enabled the French astronomers to compare the results with the data on which they depended, and in this respect not even M. Biot ventures to assert that there was reciprocity, as he merely says, that the latitude *deduced from the observations* was communicated. Again, too, it may be noticed, that there is no distinct recognition of Captain Colby in this report, although from the letter of Colonel Mudge, previously quoted, it must be manifest that he was the principal observer on the occasion, and his skill as such had been recognised by Zach in his note to Schumacher's letter, describing the sector observations in Denmark in the following terms:—"It is with this instrument that General Mudge made the meridional observations in England, and with which he and Major Colby repeated the observations at Dunkirk. *It is remarkable to me with what admirable skill Major Colby, who has lost his left hand, observes with this instrument.*" That admirable skill as an observer every one, who ever co-operated with him, must have witnessed and admired; and his rigorous determination to maintain the utmost straight-forwardness in every proceeding of the survey was equally known to and respected by all who served under him. Early in 1820 died General Mudge, who had only recently attained that high military rank. To the scientific world he was best known as the able successor of General Roy, and as a mathematician of considerable merit, though still an adherent of the fluxional theory of Newton, and therefore not a convert to the differential calculus. The present writer, when at the Academy, enjoyed the occasional privilege of visiting at his house, and whilst participating in the friendly hospitality which he bestowed upon his young friends, and which was always distinguished by a warmth and simplicity which made them feel quite at home even with the lieutenant-governor, had ample opportunity of witnessing and appreciating that never-ceasing enthusiasm for his favourite sciences which he felt in his own heart, and desired on every occasion to instil into the minds and hearts of his young guests. Under his direction the survey maintained its high character; and under his superintendence the mathematics resumed that preeminence in the Academy, which they ought to possess in an establishment founded for the purpose of training pupils for a profession, which, though practical in its details, is scientific in its principles. The Duke of Wellington was then Master-General of the Ordnance, and actuated by that sound practical wisdom, which was one of his characteristics, he departed from the usual military routine of promotion by succession, and before appointing Captain Colby superintendent of the survey applied to the leading men of science for their opinion on the subject. Lord Fitzroy Somerset (now Lord Raglan) notified indeed to Captain Colby that such was the course pursued by the Master-General, and expressed His Grace's approval of the conduct of Captain Colby in abstaining from any private application, whether personal or through friends. The replies to the Duke's enquiries were favourable to the appointment of Captain Colby, as might have been expected; and Lieut.-Col. Hobbs, R. E., who was for many years an assistant on the Scotch survey, refers to the subject in a letter dated Ayr, Jan., 1825:—"I cannot help mentioning here, that about three years since I met Sir Humphry Davy, at a dinner party in this neighbourhood; and in speaking of the survey, Sir Humphry mentioned that soon after General Mudge's death he received a note from the Duke of Wellington, requesting him to name the person whom he might think the best qualified to succeed the General: that in his reply to the Duke he said he not only thought you the person best qualified, but it was in some measure your right, having devoted your whole life to this particular duty." An anecdote has also been preserved in the family of the late Sir Thomas Robe, R.A., which will at least be deemed amusing and characteristic, even though some may consider it a mere traditionary legend. It is said then, that the Duke sent for the celebrated Dr. Hutton, perhaps the most practically effective professor of mathematics the Academy ever had, and asked him the plain question, 'do you think Captain Colby the best person to take charge of the survey?' *The very best,* replied the Doctor; and then was about to maintain that position by sundry reasons when the Duke stopped him, saying, "Thank you, Doctor, that is enough, you have fully answered my question, and I am satisfied." On the 10th of July, 1820, he was officially appointed successor to General Mudge in the superintendence of the Ordnance trigonometrical survey; and on the 16th of December of the same year he was named by Lord Melville a member of the Board of Longitude, also in succession to General Mudge. On the 19th of July, 1821, he became brevet-major; on the 29th of July, 1825, lieutenant-colonel; and on the 10th of July, 1837, colonel. In 1819 Lieut. Robe (the late Lieut.-Col. Alexander Robe), and Lieut. Dawson joined the survey, and were engaged with Captain Colby in the observations of five stations in Scotland. In 1820 the arrangements, consequent upon the death of General Mudge, induced a cessation of the mountain work. In 1821 Captain Vetch (now consulting engineer to the Admiralty), and Lieut. Drummond (under secretary for Ireland at the time of his death), were associated with Major Colby in the observations of eleven stations, including the Islets Faira and Foula, as connecting links with the Shetland Islands; and it was after this season of extraordinary labour that Major Colby took part in the renewed observations in France. This second visit was the result of an application from the Royal Academy of Sciences, and Board of Longitude of Paris, to the Royal Society of London, expressing their desire that the operations for connecting the meridians of Paris and Greenwich should be repeated jointly by commissioners of both countries, nominated by the Royal Academy of Sciences, and Royal Society of London. Messrs. Arago and Matthieu were chosen on the part of the Royal Academy of Sciences, and Captain Colby and Captain Henry Kater on the part of the Royal Society; but though this expedition was not immediately connected with the ordinary operations of the survey the Duke of Wellington assisted it to the utmost, by attaching to it a party of Royal Artillery, and authorising the supply of tents, and every other necessary store. Captain Colby also took with him Mr. Gardiner, his former companion on the summits of so many mountains, and Captain Kater paid only a just tribute to the merits of one of the most efficient public servants which the survey ever had, when he said, that "to the talents, zeal, and exertion of that gentleman, on various occasions of difficulty, they were much indebted." The original stations of General Roy upon Fairlight Down, and near Folkstone Turnpike, which, as well as Dover Castle, had been connected with the stations on the French coast, at Blancnez and Montalembert, were not at first refound, and as the gun which marked the important station of Beachey Head had been removed, it was irrecoverably lost. The difficulty in refinding Fairlight station was the consequence of a change, since General Roy's time, in the position of the mill, the distance of which from the station, together with the angle between it and Fairlight church, had been given as means for verifying the site. Everyone who has been engaged in the troublesome operation of refinding stations after the lapse of many years, must have experienced difficulties of this kind, and have further ascertained how hopeless it is to seek aid under such circumstances, from the treacherous recollection of the inhabitants. A circular trace of the old mill revealed its former position at Fairlight, and when the centre of this trace had been adopted as the point of departure the station was found with such precision, that on digging under the theodolite, the wooden pipe by which General Roy had marked his station, made its appearance, at the depth of four feet. The writer of this memoir, having on several occasions been required to get over such difficulties, has met with many examples of the erratic character of mills, though unfortunately they did not always leave evidence equally tangible of their wanderings; and has been driven almost to despair when he has appealed to human testimony. As a preliminary towards discovering the old signal staff at Holyhead, he sent for the man who for many years had been in exclusive charge of it, and was informed by him that it had stood "just at that spot, sir, where those stones are; why, sir, I watched it for many years, and saw it removed, and those stones were exactly at its foot." Who could doubt such precise information? more particularly as the place seemed a very fitting one! The theodolite was put up, but alas! all the angles were wild, and evidently pointed to a very different locality. It was gradually moved in this direction, and the angles began to improve, whilst the signal keeper kept loudly protesting that it was leaving the right spot. At length the angles became consistent, and on removing some of the surface stones, amidst the protestations of the keeper that it would be useless to do so, the butt-end of the old staff was found, and the unwilling keeper forced to admit his error. On another occasion, in Anglesey, the published description represented the station to have been on the *highest point* of the hill, but time and agricultural improvement had so changed the surface that two small adjacent peaks appeared instead of one, and they were so vexatiously similar in height, and fitness for the purpose, as to defy selection. Well, the first person who came up was the farmer who, for many years, had been tenant of the land, and he at once pointed out one of the peaks as the true site, declaring that he remembered well when the party was there, and a gentleman who had lost his left hand was constantly looking through a glass. Such testimony was irresistible; but the telescope having been put up flatly contradicted it: then came a neighbouring gentleman who said he had frequently visited Captain Colby, and looked through the telescope, and, with even greater confidence, pointed to the other peak as the right one. The telescope was shifted accordingly, but, strange to say, it denied the truth of the squire's statement, just as decidedly as it had done that of the farmer. Here was a dilemma! falling between two stools and not another in sight to rest upon! In such a condition of perplexity it was natural to appeal to the experience of Colonel Colby, and from him was received the laconic reply:—"Never mind the testimony of any one; trust to your instrument." And in truth this advice, though conveyed in terms of characteristic brevity, was most wise; and by following it a spot was soon found where the angles perfectly harmonised with those of olden time, although the plough had worked so great an alteration in the relative condition of the surface.

In order to facilitate observing across the Channel, compound lenses, of Fresnel's construction, then new to the scientific world, were used: and M. Matthieu, and Captain Mudge, put up the first one ever used in England at Fairlight. It was formed of numerous pieces of plano-convex lenses, arranged concentrically so as to form one compound lens, three feet in diameter, through which the light of the lamp, four inches in diameter, and composed of several rings of wick, was refracted. The light far exceeded that of any of the British lighthouses, and appeared at forty-eight miles like a star of the first magnitude. This application of the lens led to its adoption for lighthouses in Great Britain, as Major Colby lost no time in communicating his opinion of its excellence and advantages to his friend, Robert Stevenson, the well-known engineer and constructor of the Bell Rock lighthouse, a rival structure to the chef-d'œuvre of Smeaton, the Eddystone lighthouse. Mr. Stevenson acknowledges the receipt of this description of the lens in his letter of the 15th of November, 1821 :—"I was much obliged by the letter you sent me of the 1st inst., relative to the French lamp and lens. I wish you could put me in the way of getting a lens, as I would put it into Inch-Keith lighthouse for trial. It will answer for a revolving light; but having seen the Tour de Corduan I cannot well understand why they should use so many lenses of the description you mention. I had once an idea of communicating your letter to Dr. Brewster, when I was with him the other day; but I thought he might wish to make some use of it, and I was not sure how you might view this. I am sure you could not make a more interesting communication to the Doctor, either for the Journal or the Royal Society." The subsequent modification of the lens cannot be here noticed; in the hands of Mr. Stevenson they were soon and successfully applied, and he always continued to recognise the part which Major Colby had taken in promoting their introduction. Robert Stevenson died in July, 1850, but his son, Mr. Alan Stevenson, thus writes to Mrs. Colby, February 3rd, 1853 :—"My father's intimacy with your late respected husband was very great, and when a boy I remember his almost daily visits to our house. There was no one whom my father more highly esteemed, and of whom I have heard him speak in higher terms as a man of great energy and devotedness in his duty. I well remember that he considered himself and the Lighthouse Board indebted to your husband for his promptness in calling his attention to the improvement of the French lighthouses, and begged me, in a history of the matter I was drawing up, to notice the fact. This I did at pages five and seven of the second part of my 'Treatise on Lighthouses,' in Mr. Weale's series. My last interview with General Colby was in Dublin in 1830, when on returning from a harbour survey in the west of Ireland I gave him some heights, which, not finding to agree with the Ordnance observations, he immediately (before I left him) made the subject of a communication to the officer on duty in the district whence I had come. I well remember that when I mentioned this, on my return to my father, he exclaimed with marked approbation, '*Just like the man;*' and then commented at some length on the leading points of his character." Such indeed was the invariable rule with General Colby; he never blinked an alleged fault, but in a manly straightforward manner proceeded to probe and rectify it.

Having fixed the lamps at Fairlight and Folkestone stations, the party crossed the channel on the 24th September, 1821, and commenced their observations at Cape Blancnez, near Calais, and notwithstanding the prevalence of stormy weather and the casualties which usually attended it, such as the overthrow of tents, the dismounting for security sake of the great theodolite, &c., they completed them on the 7th October. On the 9th the observations were commenced at Montalambert, or Boulambert, a small fort near Boulogne, and were finished on the 14th, and the party recrossed the channel from Calais on the 17th. The observations at Fairlight and Folkestone were then undertaken in succession, and completed by the 27th, when Captain Kater observes, "With great regret we bade adieu to our much-esteemed companion, M. Arago, who left us for Paris; and as the season was too far advanced for any further proceedings, the party returned to London." This feeling of almost affectionate regard to M. Arago was fully reciprocated by that truly eminent philosopher and honourable man, as is manifest in the warm and hearty expression of his sentiments towards Major Colby, in a letter to him of October 2, 1822. In 1822, the work of observation, commenced at Hanger Hill Tower, was resumed at Fairlight, in order specially to observe Wrotham Hill and Tolsford, on both of which lamps had been fixed, and in like manner at Folkestone. Tolsford Hill was the next station (at which the angle between Fiennes and Montalembert, on the French coast, was taken), and then Stede Hill, Crowborough, Leith Hill, Wrotham Hill, Severndroog Castle upon Shooter's Hill, and Chingford followed, and completed the work of 1822, on the 18th November. In respect to this season's operations, it may be noticed, that the impossibility of observing one of the ends of the Hounslow Base, in consequence of intervening buildings, forced Major Colby and Captain Kater to connect their triangulation with the survey distance, Severndroog Castle to Hanger Hill Tower, as these were the nearest stations to the base which could be identified with precision. Chingford was a new station, established on the temporary meridian mark of the Greenwich Observatory, and was selected in order to make one side of a triangle coincident with the meridian, and thus to obtain the means of deducing the azimuths by direct comparison with that meridian. The assistance of Lieut.-Colonel Jones, Royal Engineers (the late most distinguished officer, Sir John Jones), was promptly and efficiently afforded to the party in raising the great instrument to the top of Severndroog Castle, and covering it when there with a shed erected on the top of the tower. Great difficulty was experienced at Severndroog in seeing the signal on Hanger Hill Tower through the smoke of London, but, observes Captain Kater, " Colonel Colby at length thought of a method by which this difficulty was overcome. Tin plates were nailed to the staff upon Hanger Hill Tower, the plates being disposed above each other in certain angles, so as to reflect the sun's rays to Severndroog. This contrivance, which answers the purpose in a certain degree of the heliostat of Professor Gauss, was perfectly successful; each plate gave in succession a neat image of the sun, resembling a fixed star, which was seen through a smoke so thick that even the hill was invisible." Although this apparatus was simple in appearance, it was in every respect a true heliostat, and in ingenuity of contrivance by no means inferior to the more perfect machines of Gauss, or to the heliostat subsequently made by Drummond and used in the Irish Survey. It had indeed one advantage over them, that it required no assistant to watch and regulate it. In 1823, Colonel Colby finished the observations at Chingford with the Ordnance great theodolite, and thus completed the observing portion of this interesting repetition of General Roy's operations for connecting the meridians of the two great national observatories of France and England. Captain Kater published the results of this work in the "Philosophical Transactions for 1828," and it is most gratifying to observe the general coincidence between the new and the old distances, as determined in the present and in General Roy's operations; and although the ultimate object of this undertaking, namely, the direct comparison of the longitudes of the observatories of Paris and Greenwich, cannot be fully attained until the results of the French portion of the triangulation have been published, Captain Kater took Calais as the starting point, and adding 0° 28′ 59″ west of Paris to its longitudes, as given in the "Connaissance des Tems," the difference of longitude between Calais and Greenwich, as obtained by himself and Major Colby, namely, 1° 51′ 18·73″; he made the difference of longitude between Paris and Greenwich 2° 20′ 17·73″ in space, or in time 9′ 21·18″, which differed only 0·28″ in defect from the previous determination of Sir John Herschel by fire signals.

Captain Kater observes that "the truth of the preceding work wholly depends upon the degree of reliance that may be placed upon the base on Hounslow Heath; and as the accuracy of this is in some measure questionable, it is certainly desirable that a new base should be measured, to connect in the most unexceptionable manner the stations at Leith Hill and Wrotham. The measurement of a base has hitherto not kept pace with the progress of other geodesical operations; but the elegant arrangement which Lieut.-Colonel Colby has recently imagined for compensating expansion, and which has already been tried in Ireland with perfect success, leaves no doubt of the future accuracy of this most important part of trigonometrical operations." But gratifying as this testimony to the merits of the Colby compensating bars undoubtedly is, the comparison between the former measurements of the Hounslow Base, and its length as deduced from the Lough Foyle Bases, which has been given in a preceding page, proves that, so far as accuracy is concerned, the Hounslow Base may well compete with any other on record. The comparison of the standards is, of course, another question, and would affect the measurement equally, whatever apparatus might have been used.

In this combined French and English operation both the great theodolites of Ramsden were used, the Ordnance theodolite having completed the observations of Chingford; and it may be stated, that originally these instruments were identical, and each provided with only two microscopes for reading the divisions of the limb. This arrangement was so far imperfect as it gave the reading of any one observed object only on two parts of the circle, or of any one observed angle on four parts; and in conformity with a suggestion of Mr. Pond, the Astronomer Royal, that it would be better always to arrange microscopes or verniers in prime numbers, as 3, 5, &c., so as to divide the circle into so many equal parts, Captain Kater had four intermediate microscopes applied to the Royal Society's instrument, which, with one of the old microscopes, divided the limb into five equal parts. Major Colby, either before, or simultaneously with, Captain Kater, had two additional microscopes applied to the Ordnance theodolite, so as to divide, in conjunction with the old microscope A, the circle into three equal parts, and thus to give each reading on three and each angle on six parts of the circle; and it may be suggested that it would probably have been better to have arranged the four intermediate microscopes of the Royal Society's instrument on the same principle, by making two of them divide the circle into three parts with the old microscope A, and the other two with the old microscope B, and then to have compared the mean of A, E, F, with that of B, C, D. Both these theodolites were originally provided with a single semicircle affixed to one side of the telescope for taking angles of elevation and depression: but Colonel Colby replaced the semicircle by a circle of 12 inches in diameter, by which arrangement it became possible to reverse the telescope; and subsequently in the course of the Irish survey, he added a second circle on the opposite side of the telescope, so that the microscopes on both sides could be read in each observation. This was a very great improvement on the original construction, and rendered the theodolite a very efficient instrument for vertical or altitude observations.

In 1822 Major Colby commenced the hill season on the Mull of Oe; but being obliged to attend personally to the observations required for the connection of the observatories of Paris and Greenwich, the work of the year in Scotland was completed by Captain Vetch and Lieutenant Dawson, as it had been, in 1821, by Captain Vetch and Lieutenant Drummond. Ten stations, however, were visited in England in 1822, and observations for azimuth made at two of them. And it should be remarked, that M. Arago participated in the work of observing both in England and France; and thus made himself practically acquainted with the merits of Ramsden's instruments. In 1823, English stations alone were visited: and from that time to 1838 the triangulation of Great Britain was suspended.

The many names of Engineer officers already cited must have shown that General Colby had contemplated a military organisation of the Survey, even before the necessity of devising a new system for the Irish Survey induced him to adopt it in the fullest extension. Besides those named, Lieut. Renny, who retired from the corps at an early period, and was subsequently assistant professor of civil engineering at Trinity College, Dublin, was for a short time employed in Scotland; and Captain Gossett for a considerable time in England. And to these should be added Lieut. (now Major) Larcom, who in 1824 was first attached to the English Survey. At this period Captain Mudge acted as local superintendent, or executive officer, at the Ordnance Map Office, Tower; and during the absence of Colonel Colby, watched over the correspondence and engraving department, being assisted in those duties by Lieutenant Dawson; and in this and the few subsequent years the engraving of the English maps acquired the highest degree of excellence, and they were made more generally useful by a subdivision of the large sheets or plates into quarter-sheets. It must not be supposed that Colonel Colby was insensible to the probable result of so large an employment of military men, as it had been long before urged upon him, that under such an arrangement the survey would ultimately cease to be an independent department, and would be placed, like all other engineer commands, under the control of the Inspector-General of Fortifications. With him, however, the rule of duty was paramount, and considering, as he did, that a military organisation would be productive of incalculable benefit, he determined to adopt it, whatever might be the result in respect to his own authority, or to his permanent connection with the Survey. Had he acted differently, and continued in Ireland the old system of contract work of England, he would have retained his position as independent head of the Survey to the last moment of his life, just as his predecessors Generals Roy and Mudge had done. That he exercised wisely the power of selection of officers, at first confided to him without limitation, the names of those officers must amply prove, as scarcely one of them has remained undistinguished, either in scientific or in political life; and with them should be associated Captain Yolland, though a later selection, as he has proved himself so fully equal to the difficult task of giving to the world the published results of so much labour in a form which will maintain the character of the British Survey as a great scientific work.

In 1824 the Government determined to undertake the Irish Survey; and in that year the present annalist was first attached to that great work, and as he enjoyed during the early periods of the Survey the privilege of a most close and confidential intimacy with Lieutenant-Colonel Colby, and performed the same functions, as regards the Irish Survey, as were performed by Captain Mudge in respect to the English, he can testify to the disinterested spirit which regulated in a similar manner all the appointments of the Irish Survey. Nor does he hesitate to declare his belief that, when the state of the work rendered it necessary to part from many of the officers who had so long and so ably served under him, Colonel Colby yielded rather to the necessities of the service than to any indifference to their labours or to their merits.

The object of the Irish Survey was more enlarged in its scope than that of the English, and it became necessary therefore to frame a system which should ensure a high degree of accuracy at a moderate expense; and further than this, Colonel Colby felt that such a noble opportunity of connecting, with a topographical survey, all these collateral inquiries, by which the springs of national wealth are discovered and directed into their proper channels, ought not to be lost. The manner in which he planned and matured a system for these special purposes, whilst he steadily endeavoured to introduce improvement into every operation of the ordinary survey, will be shown hereafter; but for the present his steps will be followed only on the mountains and in the observatory. Accompanied by Lieutenant Drummond, Colonel Colby traversed Ireland from north to south in 1824, selecting the most suitable mountains for principal stations, and collecting data for determining the probable limits of altitude to be represented in the map. To the importance of this latter consideration Colonel Colby was particularly alive, as he had noticed in the English map the want of harmony of tone which had been the result of engraving isolated portions before a scale of shades had been arranged for the whole map. Whenever the inch map of Ireland shall be published, it will prove the value of these preliminary inquiries, by forming one harmonious whole, in which independently of contour lines, every gradation of shade will correspond to a definite altitude. In 1825, the Irish Triangulation commenced on the Divis Mountain, near Belfast, and as a preparatory measure, Lieutenant Murphy was sent into Cumberland and Westmorland, and Lieutenant Portlock into the Isle of Man, to recover the sites of the old stations, and to re-establish upon them either large staves twenty-five or thirty feet in height, or conical piles of stones from sixteen to eighteen feet in height. On undertaking a duty so novel to them, both Lieutenant Murphy and Lieutenant Portlock naturally inquired what had been the system adopted by their chief, and the present writer can therefore give this, his first, experience in survey duties as at least an imitation of the vigorous system of Colonel Colby. Landing at Douglas, his first object was to hasten towards North Baroole, and to locate himself at its base in a small public-house on the roadside, kept by Mrs. Looney. The next morning, as the month was June, he started with a small party of men, about three o'clock, for the summit, and was soon hard at work preparing for and erecting the object. A few hours thus employed, and the free breathing of the wholesome mountain air prepared the stomach also to do its duty; and welcome therefore was the sight of Mrs. Looney, attended by her maidens, as she scaled the summit, with kettle in hand, a store of burning fuel in an iron pot, and all the glorious appendages of a substantial breakfast. The repast was soon ready, appetite was boundless, and digestion sound, and yet the supply was inexhaustible. With new vigour the work was now resumed, and about eight o'clock, P.M., the party descended, when Mrs. Looney, whose heart was a generous one, served up a dinner, or supper, which, though it might not have suited the palates of a court of aldermen, was in quantity sufficient to gorge a company of giants. Day after day, the same hours, the same labours, and the same feasting were repeated, when, having completed North Baroole and Snea

Fell, the author took his leave of Mrs. Looney, and was somewhat astonished when, for several days' lodging, for roasting pigs of some months old, for gooseberry-pies more than a yard in circumference, and custard-puddings in half gallon jugs, and for all her journeys to the mountain-top, that lady demanded the *exorbitant sum of nine shillings!* Peace be with Mrs. Looney! and let us ask, where should the wanderer with, as our poorer brethren sometimes express it, a wolf in his stomach, go for comfort, if not to the humble inn of Mrs. Looney, at the foot of North Baroole. South Baroole then followed; but alas! there was there no inn nor liberal hostess, and though hospitality was as much alive in the peasant's cabin—now the only resource—as it was afterwards found in a neighbouring mansion, hard work for a week on milk and oatcake served as a fast to correct the evils of the preceding week of feasting. Such scenes as these had been familiar to Colonel Colby for many years of his life; scenes wild and occupations laborious, it is true, but which derived from that very wildness, from that glorious sense of freedom which seems to swell the bosom as the fresh mountain air is inhaled, a charm which dispelled from the performance of duty the very thought of labour. Never, indeed, in twenty years of intimacy, did the author hear from the lips of Colonel Colby a single expression which could imply that in exertions beyond the powers of ordinary men he had done anything deserving of a moment's notice. During the time that these operations were in progress in England and in the Isle of Man, Lieutenant Drummond had proceeded to Ireland and prepared the Divis station for the great theodolite. The season had now fairly commenced under the immediate directions of Colonel Colby, as it was his invariable rule personally to initiate all his officers in their duties, and Lieutenant Drummond was the only one who had already passed through this training. Captain Orde (now Lieutenant-Colonel Orde), the late Captain Henderson, who subsequently, in conjunction with Mr. Maclear, measured a new base at the Cape of Good Hope; Lieutenants Drummond, Murphy, and Portlock, constituted the staff of officers of Engineers; and with them were associated about sixty of the Royal Sappers and Miners, part of a force which, at the recommendation of Colonel Colby, had been trained at Chatham under Sir Charles Pasley, K.C.B., for survey duties, their instruction having been superintended by Lieutenant (now Lieut.-Colonel) Streatfield, R.E. This, though to most a season of instruction, was indeed a noble season, as the operations had, with Colonel Colby's usual comprehensive view of the subject, been made to combine the use and observation of every description of meteorological instrument, including all those recently invented by Professor Leslie, so that the camp on Divis became a school not merely of geodesical but of meteorological science; and though the difficulty of moving such delicate instruments from hill to hill, and preserving them from injury amidst the mountain storms, obliged Colonel Colby to abandon the use of some of them in subsequent stations, enough were retained to add the skill of practice to the theoretical knowledge which had been acquired at that first and most instructive station. The duty was divided amongst the officers according to a regular roster, and the officer of the day was called at the earliest dawn to rise, and kept watch on the weather. If the hill continued clear of fog, he called Colonel Colby at the moment when the light became sufficient to prepare for observation, and without an instant's delay he came to the observatory, and proceeded to observe all the more difficult and distant objects which were practicable, leaving the officer on duty, when sufficiently trained, to observe minor objects, the other officers assisting him by reading the microscopes. Except when absent selecting new stations, Colonel Colby continued this steady course of observation when the weather permitted, or of calculation in his marquee when clouds on the summit of the hill closed it up from external observation, as was occasionally the case for many successive days, without a symptom of weariness, until November, when he left Lieutenant Henderson in charge of the instrument, and the season terminated by the observation of Drummond's Light, on Slieve Snacht, a mountain in Innishowen, on which Lieutenant Drummond patiently prepared his oxygen gas, and watched and directed the light. The distance was sixty miles, and the light appeared like a star of the first magnitude, being visible by the naked eye. The station of 1826 was Slieve Donard, in the county of Down; and whilst on this occasion the author proceeded to Wales and Anglesey, to refind stations and erect objects, Lieut. Larcom proceeded to Slieve Donard to prepare it for the great instrument, and thus commenced his connection with a survey in which he afterwards filled so important an office. The author, as soon as he had finished his work in Wales, joined him there, and having put up the instrument, began the observations. Colonel Colby came to the station immediately afterwards, with Captain Pringle, who had been appointed to the Survey, as well for his mineralogical knowledge, he having studied at Freyberg under Mohs, as for his general talents, and with Lieutenants Drummond and Murphy, and continued until November, pursuing the same indefatigable course of observation, early and late, and regardless of the discomforts which more than one fearful tempest spread over the camp. He then left the mountain, and the author completed the observations of the station about the 4th of November, Lieut. Larcom reflecting to him with a heliostat from Anglesey, when the party descended, looking, as they wended their way through the deep snow, each carrying his load, like actors in the polar scenes of Parry, Ross, and Franklin. The personal superintendence of the great triangulation was from this time confided to the author, but Colonel Colby still continued to pay him an occasional visit, and to enter with his wonted ardour into the duties of the observatory; nor was it his custom to make these visits on stations of easy and pleasant access, but, on the contrary, he usually selected the most difficult and remote. It was thus that he appeared on Sawell, a mountain in a wild district of the county of Derry, early in a most gloomy morning, which had followed a night in which the wind had raged with almost unexampled fury, overturning in dire confusion the tents of the men though protected by walls of turf, whilst the rain deluged them, and obliging the author to dismount the great instrument, amidst the crash of all around, and in darkness only broken by the flickering light of a lamp, and remove it, step by step, at each lull of the storm, to the shelter of the cook-house lower down. Colonel Colby assisted in restoring it to its position, and seemed to enjoy the spectacle of desolation, as it proved to him that his example of unshaken nerve on such occasions had not been lost upon his officers. Again accompanied by Lieutenant Larcom, he visited the author on Cnocanafrion, in the county of Waterford, a very picturesque station, as the observatory was placed on a stage, erected against the face of a rock, the actual peak of which was the station, and stood on the very brink of a precipice. From this noble and rugged mountain crag, Colonel Colby looked over the varied and vast expanse of mountain, plain, and sea before him with a fervid enthusiasm; and it was from the readiness and warmth with which he thus on all occasions identified himself with the feelings of his officers, and made himself one with them in thoughts and acts, that his visits were so welcome, so encouraging, and so profitable.

Turning from these recollections of unalloyed gratification, the visit to Kulteagh, or Culcagh, was one of painful interest, as Colonel Colby was then accompanied by the late Sir James Carmichael Smith and Lieutenant-Colonel Hoste, R.E., who were acting as commissioners of inquiry into the management and progress of the Irish Survey. Culcagh, a lofty mountain near Swadlinbar, on the borders of the counties of Cavan and Fermanagh, is rendered laborious, if not difficult of access, by a deep and much fissured bog at its base; and it was up this mountain that the commissioners were conducted by Colonel Colby, in order that they might see the system pursued in the great triangulation, and for themselves question the present writer on its merits; and if, as they certainly did, they toiled, panted, and blowed upon their ascent, envying, no doubt, the elastic and never-faltering step of their more experienced comrade, they appeared, on arriving at the summit, to forget their fatigues and to be repaid for their exertions. On this mountain the new observatory was first pitched; the old canvas sides having, with the exception of a rim at the top of about nine inches deep, been replaced by framed wooden panels, tied together with iron clamps, and secured in a similar manner to the posts, or pillars, which supported the roof. This alteration was planned by the author; and though in itself very simple, gave to the observatory a degree of stability and security which banished from the observer's mind those terrors which had before haunted and harassed him in stormy weather. Not far from the great observatory stood a miniature one, exactly similar in construction to the other, in which were the various meteorological instruments. The observatories, the marquee, and the tents, partly sheltered by hummocks of rock, and surrounded by stone walls, and the smoke-begrimed gipsy-like cook-house, formed a picture in which the soldier visitors must have recognised many of the features of a military campaign, though lighted up by the fire of science and not of war. Both Sir James Carmichael Smith and Lieutenant-Colonel Hoste, expressed the highest admiration of what they saw: but alas! whilst they praised the executive officer, they overlooked or failed to appreciate the merit of the man who had planned the work which the other executed, and thus fell into that error which has been only too common in estimating the services and talents of General Colby.

The Survey of Scotland, which had been suspended for many years, was resumed in 1838, and on this occasion Colonel Colby once more appeared on the mountains, again to perform on Ben Hutich the part of an instructor, his assistants being Major Robe and Lieutenant (now Major) Robinson; and as this appears to be the last time of his taking the field, the record of this section of the stirring life of a man of ceaseless activity and boundless energy must here with a sigh be closed.

It is hoped and believed that enough has been said in the preceding narrative to illustrate the remarkable character and the services of General Colby in one branch of the duties he so ably performed; but were it not so, the vivid sketch of a season's doings, which Major Dawson has drawn up from the letters which he wrote at the time, and kindly contributed to this memoir, would more than supply the deficiencies. The author gives this sketch in Major Dawson's own words, and feels assured that the perusal of it will leave on every reader's mind a deep impression, not only of the zeal, energy, and abilities, but also of the moral worth of General Colby.

Dear Portlock,—

You have asked me for an account of a year on the hills with our late chief, General Colby, and I will give you the first that I was out with him, which I am the better able to do, as I find that the letters which I wrote to my family that year from the hills have by chance been preserved.

In the month of May, 1819, Lieutenant Robe (the late Lieut.-Colonel Robe, R.E.) and myself were appointed assistants to Captain Colby on the Trigonometrical Survey; and on the 5th of June following I embarked in charge of a selected party of artillerymen, the instruments, and camp-equipage, for Aberdeen; at which place Robe joined the party, and, after disembarking the stores, &c., and hiring cars for their conveyance, we set out on Tuesday the 15th of June for Corrie Habbie or Cathadh, a mountain in Banffshire, which had been selected by Captain Colby for our first station.

It was our intention to march only to Inverarie (sixteen miles) the first day; but the men surprised us with a petition to be allowed to go on to Huntley (thirty-eight miles); to which we assented. We were there joined on the following morning by Captain Colby, he having travelled through from London on the mail coach, with a rest probably of only a single day at Edinburgh; the journey occupying at that time four or five days and nights. This was Captain Colby's usual mode of travelling: neither rain nor snow, nor any degree of severity in the weather, would induce him to take an inside seat, or to tie a shawl round his throat; but, muffled in a thick box-coat, and with his servant Frazer, an old artilleryman, by his side, he would pursue his journey for days and nights together, with but little refreshment, and that of the plainest kind,—commonly only meat and bread, with tea or a glass of beer.

From Huntley Captain Colby proceeded with us on foot; and on the second afternoon we reached the base of the mountain in Glen-Fiddick, near to a hunting-lodge of the Duke of Gordon. Here, by partially reducing the loads on the cars, and by the application of guy-ropes to support them, and with the men's shoulders to the wheels, we climbed up as far as we could, and, having unloaded the cars, made an irregular kind of encampment for the night. It was a fine evening; and we had need, therefore, of but slight covering; and anything like luxury was of course out of the question. A marquee was pitched for Captain Colby, in which he slept, in his clothes, on a bundle of tent-linings; and I, knowing no better, was content to put up with the like accommodation; but Robe, who had recently been with the Army of Occupation in France, like an experienced campaigner, set to work with his Portuguese servant, Antonio, who had also been with him on the continent, and soon put up his camp bedstead, and made himself much more comfortable—a lesson which I did not fail to profit by in my after-experience.

On the following morning the really laborious part of the business commenced, that of conveying the camp-equipage, instruments, and stores, to the top of the mountain. Horses were hired for the purpose, and made to carry the packages slung like panniers over their backs, so far as the ground proved tolerably even and firm; but, when it became broken and hummocky, which is so commonly the case with peaty soils, or springy and wet, there was then no alternative but to unload the horses, and carry the things on the men's shoulders; and it was surprising to see the loads which some of them would carry for miles, over ground which inexperienced lowlanders might find it difficult to traverse on foot without any incumbrance. After encouraging the men for a while at the outset of their laborious undertaking, Captain Colby went on, taking Robe and myself with him, to the summit, where he selected a spot of ground for the encampment as near as practicable to the station, and also for the watch-tent at a point much nearer still. He then selected a suitable place for a turf-hovel, to be built on the sloping face of the hill, with a tarpaulin roof, in which to make a fire for cooking, and for drying the men's shoes and clothes, and to serve also as a place of shelter and warmth for the men in tempestuous and severe weather. When some of the tents had been brought up, and one or two of them pitched for present use, a party of the men were withdrawn from this duty, and employed in pulling down the conical pile of stones built round the station-staff, and in setting up in its place the observatory-tent. The requisite steps were then taken for securing the table or stand for the great theodolite; and the theodolite itself was then brought up with special care and fixed in its position.

In all these proceedings, here and elsewhere, Captain Colby invariably took an active part; and he would never sit down to rest or take any food or refreshment until everything had been satisfactorily accomplished and secured.

Corrie Habbie is elevated about 2200 feet above the mean level of the sea. Like most of the other mountains in its neighbourhood, particularly to the northward and east, it is a long round-backed hill, rising gradually towards the south. It is of the quartz-rock formation, and covered with a heathy peat-moss, except on the summit, and a few bare patches on the sides, which show the whitened surface of the quartz-rock. To the westward, at a distance of about six miles, Benrinnes, a conical mountain, rises a few hundred feet higher than Corrie Habbie. Still further off, and extending towards the south, the Monagh Lea range rises to the height of 3500 feet, and to the southward extends the Grampian range, with the mountains of Cairn Gorm and Ben Macdui in the foreground.

When the arrangements in the observatory had been completed, and the summit of the hill was free from clouds, every moment favourable for observation was anxiously caught by Captain Colby, and devoted to that service, from sunrise to sunset. At other times he imparted to Robe and myself a knowledge of Ramsden's great three-foot theodolite, and of its adjustments, as also of the mode of working and entering the computations; explaining still further the position and names of the principal mountains and trigonometrical stations within the range of observation.

*Monday, 21st of June.*—After a stormy day the clouds suddenly broke away about seven o'clock in the evening; and at eight o'clock, under very peculiar circumstances of refraction, Captain Colby discovered and showed to us, through the telescope, a brig under sail to the northward, at a distance which he considered could not be less than 100 miles.

*Monday, 28th of June.*—At eleven o'clock, A.M., the thermometer, having previously stood at 50°, went down suddenly 5° at noon, when a tremendous storm of hail came on and covered the ground several inches in a few minutes. The hail-stones were large and conical, with smooth convex bases and striated sides.

The hail continued till about one o'clock; after which snow fell for an hour or so, and then sleet and rain. We were forced to be out shovelling the hail and snow from the tents while the storm lasted, and when gone the men set-to snow-balling one another as a means of warming themselves—a rather unusual amusement at the latter end of June. At this time the temperature at night was generally from 35° to 38°, and this was not complained of as being cold, but rather the contrary. With the thermometer at temperate the heat was considered oppressive.

*Tuesday, 29th of June.*—Captain Colby took Robe and a small party of the men on a "station hunt," or pedestrian excursion to explore the country, along the eastern coast of Invernesshire, Rosshire, and Caithness, and to erect objects upon some of the principal mountains, and select those which, from their position and circumstances, should be preferred for future encampments. That particular season of the year was usually taken for the purpose; because, owing to the tremulous state of the atmosphere, it is unfavourable for instrumental observations, excepting occasionally for an hour or so after sunrise, and for a like period before sunset; at which times, unless the summit of the mountain chances to be free from clouds and mist, nothing really valuable, in the way of observation, can be done. The opportunities afforded for the purpose are indeed extremely capricious and uncertain at other times also: it was no uncommon occurrence for the camp to be enveloped in clouds for several weeks together, without affording even a glimpse of the sun or of the clear sky during the whole period. And then in a moment the clouds would break away or subside into the valleys, leaving the tips of the mountains clear and bright above an ocean of mist, and the atmosphere calm and steady, so as to admit of the observations for which the party had waited days and weeks to be taken in a few hours. It may be imagined how perplexing it is at such times to receive visitations from the gentry of the neighbourhood, which otherwise would be highly acceptable. And although nothing could, under favourable circumstances, exceed the good-nature and patience which Captain Colby showed even to the humblest of his visitors—gratifying them with a peep through the telescope at some familiar object; and then, by means of the prismatic and inverting eye-pieces, exciting their astonishment by showing them the same object apparently in a different direction, or standing upside down; so on the contrary nothing appeared to worry him more than the approach of visitors when we were really at work, and whatever might be their rank, he would then scarcely speak to them or show them even common attention.

Our post town, while on Corrie Habbie, was Huntley; and one or other of the men was sent there for letters and bread, when they could be spared for the purpose. The distance in a right line was eighteen miles, which Captain Colby considered to be equivalent to twenty-four.

*Wednesday, 21st of July.*—Captain Colby and Robe returned to camp, having explored all the country along the eastern side of the counties of Inverness, Ross, and Caithness, as well as the mainland of Orkney, and having walked 513 miles in twenty-two days.

*Friday, 23rd of July.*—Captain Colby took me and a fresh party of the soldiers on a station-hunt, to explore the country to the westward and northward of west. Our first halting-place was to be Grant Town, at a distance of twenty-four miles; and Captain Colby having, according to his usual practice, ascertained the general direction by means of a pocket compass and map, the whole party set off, as on a steeple-chase, running down the mountain-side at full speed, over Cromdale, a mountain about the same height as Corrie Habbie, crossing several beautiful glens, wading the streams which flowed through them, and regardless of all difficulties that were not absolutely insurmountable on foot. Sometimes a beaten road would fall in our course, offering the temptation of its superior facilities to the exhausted energies of the weary members of our party; and in such cases freedom of choice was always allowed them. Captain Colby would even encourage such a division of his party and the spirit of rivalry which it induced, and took pleasure in the result of the race which ensued. Arriving at Grant Town in about five hours and-a-half we dined there, and proceeded afterwards along the valley of the Spey, by the high road, to the Aviemore Inn to sleep. The distance travelled by us that day was calculated at thirty-nine miles.

*Saturday, 24th of July.*—Started at nine o'clock. I was dreadfully stiff and tired from the previous day's scramble, and with difficulty reached Pitmain (thirteen miles) to dinner. The country helped me considerably, for it was beautiful,—Rothiemurcus, on our left being one of the loveliest places that I had seen. A good deal of brynny mountain ground, richly clothed with wood and plantation, rises immediately at the back of the house;—to the right are green rocky hills and not a tree to be seen.

Garviemore Inn, distant eighteen miles by the road, was to be our next stage, and I really thought it was more than I could possibly accomplish that day, but Captain Colby said it was not. It was his intention, however, to leave the beaten road immediately, and, crossing a rough boggy tract of country to the northward, to gain the summit of Cairn Derig, a mountain, about 3500 feet high, and about ten miles distant, and having built a large pile of stones upon it, to proceed thence again across the country to Garviemore, making the distance of course considerably greater, and the journey much more laborious, as I thought, than by the road. I petitioned strongly, therefore, to be excused from accompanying him, and to be allowed to proceed quietly along the road with the serjeant and another man, who being equally tired had also blistered their feet, and to whom it was on that account allowed; but Captain Colby would not excuse me, and I had no alternative but to make the attempt, feeling sure that I should eventually be left upon the ground, or carried home upon the men's shoulders. Captain Colby judged, however, from accurate observation and long experience—and he was right—I kept pace with him throughout the remainder of the day, and arrived at the Inn at half-past eleven o'clock at night, much more fresh than at the end of our first stage the day before. The second day on such a journey is generally the worst—but the first had broken me in. I could have proceeded further if it had been necessary, and never experienced anything like fatigue throughout the remainder of the excursion. The distance travelled that day was forty miles.

*Sunday, 25th July.*—There being no church in the neighbourhood, we strolled out soon after breakfast to see the country, being then in the very heart of the mountains. From the opposite side of the road, to the southward, the ground rises suddenly to the height of about 1500 feet. This we ascended, and found, as is frequently the case, an eminence of greater elevation behind it. Having gained this second elevation, a third appeared, and so on to others in succession: though frequently in pursuing our straight course we had to descend rocky valleys, and thus to lose in a quarter of an hour the elevation which it had cost half an hour's severe climbing to attain. In this way, however, we at length reached the summit of Bui-Annoch, a mountain rising suddenly from the wooded shores of Loch Laggan to the height of about 4000 feet. From that point we obtained a splendid view of the western hills for which we were bound—a white and serrated range extending from the west to the northward as far as the eye could reach. To the north extended the Monagh Lea range, east and southward the Grampians, and to the south-west,—distant about twenty miles,—Ben Nevis, in his gigantic proportions, stood out boldly in the foreground, the acknowledged chief of this stupendous array. I have since traversed Switzerland, and the view of the Alps, is in my opinion, scarcely more imposing than this. In these days of steamboats and steam carriages, the journey to Garviemore would be amply repaid by the mountain view from the summit of Bui-Annoch. After dwelling upon it for an hour or two, and refreshing ourselves with a copious draught from a pure spring surrounded with icicles and snow, we returned to Garviemore, having walked about four-and-twenty miles, and attained so great an elevation on the day which should have been our day of rest.

*Monday, 26th July.*—Starting soon after daybreak, we followed the road over Corrieharrack, a mountain about 2000 feet high, in crossing which the road is zigzagged and marked with poles to trace its course in the winter when covered with snow. This mountain is said to afford the finest view in Scotland, and so it may to those who cannot go upon Bui-Annoch. Descending to Fort Augustus, eighteen miles, we proceeded thence, in a north-westerly direction, twenty-two miles further, to a place marked Cluny upon the map. The first part of our route from Fort Augustus was along the line of one of the old military roads of General Roy, which, passing over an inferior mountain range, and descending into the valley on the other side, fell in there with the parliamentary road, made by the late Mr. Telford as a communication with the Isle of Skye, and which arrives at this point from Fort Augustus by a very circuitous route. We then kept the road for the remainder of the day's journey, through a desolate mountain tract without meeting any living beings but a few small birds. The inhabitants had been driven out, to convert the district into a sheep-farm, and the remains of their habitations were occasionally to be seen by the road-side. There we could also trace the sites of the encampments used by the workmen in making the roads: and, shut in as the road is among the mountains, a more dreary and melancholy journey it is impossible to imagine. Arrived at Cluny, we found it to consist of only a few miserable mud-hovels, one of which, being a public-house, was to be our abode for the night. The sitting-room we occupied in common with two drovers, who, having arrived somewhat before us, had secured possession of the only two bed-places, which were built into the wall like the berths on board ship. The tail-end of a salmon was produced for our supper, but it was so stale that we were unable, even after our long walk, to eat it, and we thankfully partook of a mess of oatmeal-porridge with goat's milk in lieu of it; after which, upon three or four wooden chairs, placed as evenly as the earthen floor would permit, and with our knapsacks for pillows, and our short walking-cloaks for a covering, we settled ourselves to rest for the night.

*Tuesday, 27th July.*—It may be inferred that our departure was not delayed much after daylight this morning, and that on our arrival at Invershiel, at the head of Loch Duich, to breakfast, we partook with no slight satisfaction of a fine salmon, brought almost alive from the fishery in front of the Inn. We proceeded afterwards to Scour Ouran, a high mountain to the north-east, being one of the serrated main range before spoken of, and, having built a large conical pile of stones on its summit, we returned to the inn at Invershiel to sleep.

*Wednesday, 28th July.*—Crossing the Kyle Rea ferry into Skye, we proceeded to Broadford, and thence to Sconser, a distance of about two and thirty miles, and the following day made an attempt to reach the summit of the Coolin hills, but were completely foiled in the attempt, and that was probably the only instance in which Captain Colby was ever so foiled. Nothing that I have seen can, for savage grandeur, bear comparison with these mountains. They appear to be of a basaltic formation, about 3000 feet high, the upper portion of which, for about 100 feet is a perpendicular and partly overhanging black rock, which, under the influence of time and the seasons, has broken away, and completely covered the ground with débris for about a thousand feet.

This mass of débris, standing at the steepest angle that will retain it in position, requires but a trifling additional disturbing cause to set a large mass of it in motion; and it was necessary to use the greatest possible caution with our party in traversing it obliquely, to avoid the displacement of even a single block of any magnitude, which might bring down the superincumbent mass like an avalanche to sweep us away.

Not being provided with ladders or ropes, the perpendicular rock at the summit effectually baffled our efforts for several hours to find a crevice by which to ascend it. We gained, however, a ridge which reaches out from the perpendicular cliff with a superb column at the extremity of it, and so narrow is this ridge that we were obliged to sit astride upon it, in which position little more than the strength of an infant was required to hurl a stone to the bottom of the corrie on the south side, without impinging upon the face of the cliff, a depth of about 2000 feet. After admiring for a while the magnificence of the prospect, and the dreary and all but chaotic scene around us, we returned to our inn, gratified above measure with what we had seen, though disconcerted with our professional failure.

*Friday, 30th of July.*—The higher mountains being enveloped in clouds, Captain Colby hired a boat, and we sailed to Portree, a small town about ten miles to the northward, whence we proceeded to the range of hills above it, and, having erected a pile of stones upon one of them, we returned again to Sconser.

*Saturday, 31st of July.*—A bright morning at daybreak, and we were on foot again to make a fresh attempt on Scour-na-Marich, another head of the Coolin range, which Captain Colby had singled out for the purpose, on the former occasion; and this time our effort was crowned with success. Having built a large pile upon it, we returned to our inn to breakfast, which by that time we stood much in need of, and, hiring a boat, we proceeded direct to Jeantown, at the head of Loch Carron, on the west coast of Rosshire.

*Sunday, 1st of August.*—In the course of the morning, as we were looking at the map to ascertain our position and the probable course of our journey for the ensuing week, I so far forgot the sacred nature of the day as to commence whistling some light air. Captain Colby very properly checked me in so doing, explaining to me the deep sense of veneration with which the people of that country regard the observance of the Sabbath, and the next day I was informed, while on the march, by one of our men, that he had been urged by the landlord to come to me and beg me to cease whistling, dreading lest some judgment should otherwise fall upon his house. There can be no doubt that I was wrong, and that Captain Colby and the landlord were right. We explored that day the mountains to the north-eastward, and built piles upon some of them, passing on afterwards to the upper end of Loch Maree, thence by boat to the lower end of the loch, and by road to Gairloch at night.

Those who have traversed the mountains on the western coast of Scotland in the autumn, may be familiar with the effect produced by the bites of the midges, which swarm there at that season. The heat also then being intense, it was our practice in walking to put our coats and waistcoats into our knapsacks, and thus, with our shirt necks thrown open, and our sleeves tucked up, we were exposed in a peculiar manner to the baneful attacks of those venemous insects. On the occasion referred to, we suffered very severely; our arms, necks, and faces, were covered with scarlet pimples, and we lost several hours' rest at night from the intense itching and pain which they caused. Even at the inns we had frequently to smoke in our bed-rooms and over our meals to drive these insects away.

*Tuesday, 3rd of August.*—While at breakfast this morning, we received a visit from Sir Hector M'Kenzie, the chief proprietor of that district, from whom we afterwards learnt that the landlord of the inn had hastened to apprise him of our arrival, intimating that we ought to be the laird's guests and not his. As the country was then covered with mist, down to the water's edge, Captain Colby had no hesitation in accepting the proffered hospitality of our kind host, and we spent a few days most happily at his house, during which time the atmosphere, fortunately for our personal comfort, though not for our professional duties, continued unchanged.

In one of these days we were suddenly summoned to assist in restoring a drowned man, a poor shoemaker, who, after a long day's work in repairing our men's shoes, had gone to bathe and got out of his depth. Captain Colby at once undertook the management of the case. He was familiar with the ordinary rules of the Humane Society, and, taking off his own coat, he proceeded himself to do, and direct others to do, what was necessary for fully three hours; but unhappily without effect. The body had been too long in the water, and life was extinct.

The sun at length burst forth again, and we proceeded on our march. We were supplied by our kind host with an introduction to a friend of his, at Letterew, on the northern shore of Loch Maree, which secured us a hospitable reception there also; and, had there then been a prevalence of misty weather, or had our object been pleasure, we might, I believe, have remained, or have been passed on in a similar manner from one hospitable mansion to another for almost any indefinite period. For one night only could we profit by it on that occasion; and, after exploring the country to the eastward, and building piles upon the mountains which were best placed, we descended to Loch Fannich where, at a comfortable inn on the roadside, we spent the evening with the proprietor of the estate, who occasionally made it his residence during the shooting season. He informed us, that in the previous season, some sportsmen from England, to whom he had granted permission to shoot, killed at the rate of fifty brace of birds to each gun per diem, and left the birds where they fell upon the ground.

The next morning we proceeded onward to Beauley and Inverness; thence, on the day following, to Grant Town; and on Saturday, the 14th of August, returned to the camp on Corrie Habbie, having walked 586 miles in twenty-two days, including Sundays, and the days on which we were unable to proceed from bad weather.

In addition to the ordinary hill fare of boiled mutton, broth and plum-pudding, our dinner that day consisted of boiled salmon and grouse, with vegetables and fruits of various kinds and of the finest quality; ale, porter, and wine. For this we were indebted to the liberality of the Duke of Gordon, who was then at Glen Fiddich. He came up frequently to see Capt. Colby; and his bountiful provision was continued to us while we remained on that hill, and included also the men who were there encamped with us.

*Wednesday, 25th of August.*—The thermometer in camp yesterday stood at 75° at noon. This day it was 45°, and we were hard at work in the observatory from eight o'clock in the morning till eight at night. The distant hills were extremely clear, except to the north; and we saw the pile on Ben Nevis very distinctly through the telescope, at half-past seven o'clock, after sunset, the distance being seventy-five miles in a right line. The sudden change of 30° temperature in one day was very sensibly felt by us in our exposed situation, and with the instruments in our hands for so many hours. But we were thus enabled to complete the observations on this and the three following days.

*Tuesday, 31st of August.*—We arrived at Inverness last night, and found the town in commotion, expecting the arrival of Prince Leopold of Saxe Coburg. He came this day with the Marquis of Huntley, and as we chanced to be at the same inn, and in the next room, Sir Robert Gardner, who was travelling with the Prince, called on Captain Colby, and introduced us both to His Royal Highness. Nothing more was requisite to ensure an invitation for us to the entertainment provided for him in the evening. On that occasion we were fortunate also in meeting with Captain, the late Lieut.-Colonel English, R.E., then commanding the Royal Engineers at Fort George, who promised to visit us on our next station, Ben Wyvis, and bring up with him Colonel, the present Sir John Fox Burgoyne, G.C.B.

*Friday, 3rd of September.*—We arrived at the summit of Ben Wyvis this afternoon. The mountain is about twelve miles N.W. from Dingwall, and 3400 feet high. The top of the hill was covered with a dense fog, which continued with heavy rain and wind for several days. Mr. Adams, the Rector of the Academy at Inverness, and Captain M'Claren, of Dingwall, ascended the hill with us; and after partaking of such refreshment as we could give them, they departed homeward, and I accompanied them through the fog, and over the worst ground. They contrived, however, to miss their way afterwards, and wandered about over the rough boggy ground until one o'clock in the morning, when they fortunately reached the place where two of our round tents were pitched, about half way between the station and Dingwall. Here they were glad to eat a mess of oatmeal, mixed with cold water, and to sleep in a blanket upon the baggage, which was piled together for the night.

*Friday, 10th of September.*—Barometer 26·487 at noon. Thermometer 43°, and at night 39°. This and the preceding day were fine, and we were at work in the observatory from six o'clock in the morning until seven in the evening; the field of observation including Cairn Gorm, Ben Nevis, the hills in Skye, and the long range of precipitous mountains extending northward, almost to the north coast, with a considerable tract of cultivated ground extending eastward to the Murray Firth. The whole constituting a panoramic view of no ordinary kind.

*Sunday, 12th of September.*—Three of the tents blown down last night. I was despatched to Fort George this day—twenty-nine miles—to prosecute, on the morrow, two of our men for absenting themselves without leave, and striking a non-commissioned officer. I returned to Dingwall on Tuesday, and found that the party had left the hill, and gone northward. Starting by the mail on Wednesday morning I overtook them at Latheron in Caithness.

*Saturday, 18th of September.*—Erected the observatory on Bein Cheilt, a hill about two miles west of Latheron, and 1200 feet high. The ground, a perfect peat moss, and the country around it very uninteresting, the Scarabin hills and the rocky pass of Caithness, to the southward, being the most pleasing objects in the landscape. Ben Wyvis, in the distance, was seen covered with snow.

*Wednesday, 22nd of September.*—Completed the observations last night, and packed the instrument in its waggon. This day we travelled back about forty miles to Goltspie, and proceeded to Bein Loch cas na Cairoch, a mountain about four miles to the westward of that place. Here again the ground was a perfect bog, and wetter even than at Bein Cheilt. The season too had now changed; we had frequent and violent storms of hail, rain, and wind, which occasionally threw down some of the tents; but in the intervals the atmosphere was clear, and allowed of the instrument being constantly at work. September is in fact considered one of the best months for the trigonometrical survey; and, contemplating a speedy removal to another station, Colby ordered the camp to be pitched about a mile and a half from the observatory, at the outlet of a secluded lake, which was reported in the neighbourhood to be haunted.

Acting upon the suggestion thus offered, some of our men prepared a large turnip lanthorn, which at night they set floating at the upper end of the lake with a light westerly breeze. Attention was quickly called to this unexpected appearance, and some of the most venturesome of the party set out along the shore of the lake to ascertain the cause of it. The night being perfectly dark, the light, seen from the water's edge, appeared to be always on the opposite side of the lake, and the party made the complete circuit without obtaining the desired information.

It was then proposed, and by some of the party rather reluctantly assented to, that two parties should set out—one on either side of the lake—and this time, by the merest chance, as the two parties by their shouting, found themselves nearly opposite to one another, and each thought the phantom within the others grasp—the light suddenly went out—and the disappointed and disconcerted inquirers returned to camp, with the conviction that "such things should not be enquired into." The next morning, very early, the lid of the camp-kettle was picked up in the little stream near our tent doors; and I much question whether, to this day, those who saw and heard of it are persuaded that it was only a successful trick.

*Wednesday, 29th of September*.—The observations were finished last night. This morning being fine, the tents were taken down and packed dry, and sent by water to Tarbat Ness, the north cape of the Murray Firth. The great theodolite in its waggon was sent round by land, and Captain Colby, Robe, and myself, proceeded also by the road, through Tain. There we had the gratification of witnessing a Highland meeting,—Glengary, with his brother chieftains and their pipers; and, as a consequence, we obtained bad accommodation and little rest.

The station at Tarbat Ness is only 200 feet above the sea and 500 yards from it, upon hard, dry ground, and the observations occupied but a week or ten days. The weather was now daily becoming more stormy and wet. The mountains were all covered with snow, and the trigonometrical season was declared to be at an end.

After seeing the instruments safely packed, the keys of the provision chests were, according to established custom, given to the men, who received also from Captain Colby a carte blanche to provide themselves with a farewell feast. The chief dish on such occasions, was an enormous plum-pudding. The approved proportions of the ingredients being, as we were told, a pound of raisins, a pound of currants, a pound of suet, &c. to each pound of flour; those quantities were all multiplied by the number of mouths in camp, and the result was a pudding of nearly a hundred pounds weight. Every camp kettle was in requisition for mixing the ingredients—some breadths of canvas tent-lining were converted into a pudding cloth,—a large brewing-copper was borrowed to boil it in,—the pudding was suspended by a cord from a cross-beam to prevent its burning, and it was kept boiling for four-and-twenty hours—a relief of men being appointed to watch the fire and maintain a constant supply of boiling water. A long table was spread in three of the marquees, pitched close side by side and looped up for the purpose—and seats being placed also for Colby and his subs., we partook of the pudding which was excellent, and withdrew, after drinking "*Success to the Trig.*"

Such had been Captain Colby's course of life for many years before I joined the Survey, and the season of 1819 was nearly his last. He was out in 1821 with Vetch, Drummond and myself in Orkney and Shetland, and upon the two lone islands of Faira and Foula, on the last of which Captain Colby experienced a severe inflammatory attack, and had to send to Lerwick, on the east coast of Shetland, for leeches, his sufferings in the meantime being almost beyond endurance. In 1822 he was out again with Vetch and myself on the west coast, and taking me with him, explored the whole range of the Western Islands, from the Mull of Cantire to the Butt of the Lewis, and returning to Isla he slept for one night only or two in camp at the Mull of Oe. In 1825 he was on Divis, and in 1826 on Slieve Donard, in Ireland, and that was, I believe, the last year that Captain Colby was encamped on the hills for any length of time, until the resumption of the Survey of Scotland in 1838.

Yours very truly,

R. W. DAWSON.

To persevere in exertions so arduous in their nature and degree for so many years, and yet simultaneously with them, to direct and control all the other operations of the Survey with the utmost clearness and despatch, required an union of great physical powers and of a sound intellect, seldom met with in the same person; for be it remembered that whilst by example and precept on the mountain summit General Colby was exciting in all his officers a spirit of enterprise and a habit of persevering endurance, which enabled them to triumph over all difficulties, and to smile at what many would have called privations, he was enabled to bring the English Map to that state of perfection, both of drawing and engraving, which called forth the eulogistic testimony of Lord Monteagle and Sir Roderick Murchison, in their evidence before the committee of 1851. Lord Monteagle observed,—"There is nothing in which the progress of improvement is more visible than in the English Map; but taking the English Map, we will say some of those beautiful sheets in South Wales, which are exquisite, as well as some of the later sheets which they have published, I do not think you can go in map-making beyond that.—A map which is really well engraved, as the modern maps of the Survey of England really are, are chefs d'œuvre of engraving as well as of drawing, exquisitely drawn and engraved." And Sir R. Murchison said,—"I beg to express my most decided conviction that they produce nothing on the continent equal to our best maps, as recently published in this country by our own Ordnance Survey, of which I lay what I consider a beautiful example before the committee, of a part of Wales, which I think so perfect a delineation of the country that nothing more can be called for." Unquestionably in this branch of the work he availed himself of the careful inspection of Lieut.-Colonel Mudge and of Lieut.-Colonel Dawson; and as regards the Maps of Wales, of the great artistic talents of Lieut.-Colonel Dawson's respected father Mr. Dawson; but in this, as in every other improvement, his mind expanded to the full range of requirements which a great national work demanded, and enabled him to appreciate and encourage, as well as to direct the talents of others in securing them.

In the Irish Survey this great faculty of General Colby was still more strikingly exhibited, and will be traced through the several stages of that work which may be emphatically called his own; as he not only planned the system on which it has been so successfully accomplished, but even invented the most important of the instruments, the compensation bars for measuring bases, which were then for the first time employed. But before closing this record of patient endurance, of steady perseverance, and of unparalleled activity and energy, in order to study the high constructive and administrative talents of General Colby as exhibited in the Irish survey, it is only right to point out more distinctly the maxims of conduct which were naturally based on the example he exhibited, and which became the inflexible though not written rules of the Ordnance Survey.

He never allowed pleasure to interfere with duty, and hence it was that the observer clung to his mountain top with unshaken resolution, and never allowed the allurements of the low grounds to tempt him from the scene of his labours, or to cheat him out of one moment of good observing weather.

He carefully shunned any act or word which should outrage national prejudice or feeling, and this principle of forbearance enabled his officers to pass through the wildest portions of Ireland, in the most disturbed times, without exciting ill feeling or inducing opposition.

He devoted every available moment of fine weather to observation, and when baffled by fogs or storms, he calmly seated himself in his tent, and as if in the quiet of his office, proceeded with his calculations. In short, when engaged in duty, he bestowed all the energies of his body and mind upon it; and there cannot be a doubt that in this great principle of action he was closely followed by all who served under him.

Is there any one then so blind or so unjust, as to praise the successful results of the combined and unwearied labours of so many able and conscientious men, and yet to withhold from the man in the track of whose example they had trodden, and by the fire of whose spirit they had been kindled into enthusiasm, that honour to which his memory is so justly entitled?

[*To be completed next Volume.*]

# PROFESSIONAL PAPERS.

## PAPER I.

### Report on the Disputed Boundary between Canada and New Brunswick. By Major Robinson, Royal Engineers.

It will be seen by the following papers and report, that whilst Major Robinson and Captain Henderson, of the Royal Engineers, were employed in British North America for the purpose of exploring and reporting on the best direction for a line of railway between Halifax and Quebec, their attention was at the same time directed to the subject of a long-pending dispute as to the common boundary line between the provinces of Canada and New Brunswick. Report.

This dispute was as old nearly as the latter province itself, which was formed into a distinct government in the year 1784.

The primary cause of it was the very general, or rather the vague and indefinite, manner in which the boundaries of Canada were described in the Royal Proclamation of the 7th October, 1763; when it was formed for the first time into a British province out of the possessions then recently conquered from the French.

The Quebec Act, which was an Act of Parliament, passed in June, 1774, to remedy some of the defects and omissions of the Royal Proclamation, did not, unfortunately, more clearly define the "southern boundary of Canada," which was the term afterwards employed in defining the northern boundary of New Brunswick.

In the summer of 1785, being but a very short time after the formation of New Brunswick into a distinct government, it appears the Surveyors-General of Canada and New Brunswick were in correspondence, and disputing as to the limits and extent of their respective provinces between the Upper St. John's River, the Lake Tenisconata and the River St. Lawrence.

In 1787 they were appointed to meet each other in the territory in dispute, with a view to agree upon and mark out the boundary, or the route of communication then existing between the two provinces.

The Surveyor-General of Canada was instructed to guide himself by the description given of the boundaries in the commissions of Lord Dorchester, then Captain-General and Governor-in-Chief of the three provinces of Canada, New Brunswick, and Nova-Scotia. The Surveyor-General of New Brunswick was

REPORT.

instructed by the Lieutenant-Governor to guide himself by the Act of Parliament (1774) for establishing the province of Quebec.

In consequence the two Surveyors-General set off, and met each other *en route* near the mouth of the Madawaska River, at its junction with the Upper St. John.

There was no agreement, however, between them. The Canadian Surveyor-General requested him of New Brunswick to *go back* with him thirty-five miles, to fix the boundary at the Grand Falls; whilst the latter requested the former to *go on* with him about fifty miles, to fix it on the height of land overlooking the River St. Lawrence.

The question, in consequence, remained unsettled; but it soon became merged entirely, and was directed to remain in abeyance by Imperial authority until the much more important boundary dispute, which was then going on between Great Britain and the United States, should be terminated.

This great dispute, respecting the north-eastern boundary of the United States with the British provinces of Canada and New Brunswick, is now matter of history.

Arising out of the treaty made in the year 1783 with the United States, it was not settled until the year 1842, when a compromise was agreed to, and the question set at rest by dividing, as nearly as could be, the territory in dispute equally between the contending parties.

During its continuance, volumes of angry diplomatic correspondence were written: commission after commission of inquiry and exploration was appointed; and more than once war was imminent between Great Britain and the United States of America in consequence of it; the whole of which might have been avoided, if the statesmen or diplomatists of those days, who drew up the Royal Proclamation in 1763, and framed the Boundary Article in the Treaty of 1783 with the United States, had adopted more generally the use of parallels of latitude, and due north or south lines, or meridians of longitude.

In new countries, where the inhabitants are few and scattered, and their physical geography imperfectly known, no better principle can be adopted.

A parallel of latitude, or a due east and west line, is capable of being marked on the ground with the greatest accuracy.

So also can a due north or south line, provided some initial point for its commencement be given.

A second of latitude is equal to 101 feet on the earth's surface, and with good instruments and time to repeat the observations, the limit of error might be brought to about that quantity.

But if a meridian of longitude from Greenwich, or from any other distant meridian have to be fixed, the limit of error will be greatly increased.

Probably two observers would differ as much as a mile or two, or even more, in determining the longitude of any fixed point astronomically.

In new or partially explored countries, such a difference is of little consequence.

The difficulty is only in establishing the initial point for a due north or south line.

The mouth of a large river is a vague definition, but still more the source. There may be a hundred streams contributing to the one main stream, and lying, in regard to its mouth, in very opposite directions.

A river boundary, from this cause, may soon become questionable and uncertain.

REPORT.

Chains of mountains are not always continuous, but become broken and interrupted, ramifying and separating into smaller branches, until all distinctive character may be lost.

Hence originated the long pending disputes in question.

When that between Great Britain and the United States was happily terminated by the Treaty of Washington, in 1842, and while the Commissioners were tracing the new boundary fixed by it upon the ground, the old dispute between Canada and New Brunswick was revived.

Each province appealed to the Imperial Government, and hence arose the following joint report and proposed plan of settlement by the officers of engineers and their legal commissioner, Mr. Johnston, appointed under Mr. Secretary Gladstone's letter of the 2nd July, 1846.

To this boundary New Brunswick expressed her ready acquiescence, but Canada protested against it.

After a considerable delay, arising from various causes, Lord Grey suggested a plan to decide the dispute by arbitration; according to which, Thomas Falconer was chosen arbitrator by and on behalf of the province of Canada; Travers Twiss, Esq., D.C.L. was selected by and on behalf of New Brunswick; and the Right Hon. Stephen Lushington, Judge of the Admiralty Court, was chosen by them as third arbitrator, or umpire, for the decision of the question.

Early in 1851 the arbitrators met in London, and after examining and considering the documents and reports submitted to them, two of them made a report, and suggested a boundary line.

Mr. Falconer, the arbitrator on the part of Canada, refused to join in it.

The Government, however, adopted the report of the majority, and an Act of the Imperial Parliament was passed in August, 1851, by which the boundaries were defined strictly according to their decision, and a dispute of nearly seventy years' duration set at rest; it is to be hoped never to be revived.

The boundary line thus recommended by the arbitrators, and adopted by the Government, differs from that of the Commissioners; the former giving to Canada, as a matter of feeling, what the latter stated they would have done but for fear of making a complicated boundary: viz. the entire seignories of Madawaska and Tenisconata, and compensating for it to New Brunswick by the addition of a portion to the eastward of the river Kedgwick.

The line is, in consequence, less simple than that recommended by them, and will be more expensive to trace out on the ground. Some doubts may also arise in determining the points where the tangents to the highlands occur.

The line is otherwise unobjectionable.

WILLIAM ROBINSON,
Capt. Royal Engineers, Br.-Major.

*June* 14, 1852.

MEMORANDUM OF DOCUMENTS, TO FOLLOW THE PRELIMINARY REMARKS ON THE DISPUTED BOUNDARY BETWEEN CANADA AND NEW BRUNSWICK.*

MEMORANDUM OF DOCUMENTS.

No. 1.—Copy of Letter of Instructions, from the Right Hon. W. E. Gladstone to Captains Piper and Henderson, marked No. 2. Page 82 of Blue Book.

No. 2.—Joint Report of Officers and Mr. Johnston, dated Halifax, United States, July 20th, 1848. Commencing page 86 and ending page 94 of Blue Book.

No. 3.—The Topographical Report, &c., with Map. Commencing page 94 and ending page 98 of Blue Book.

No. 4.—Letter and Decision of Dr. Lushington and Travers Twiss, dated April 17th, 1851. Pages 34 and 35 of Blue Book.

No. 5.—Dr. Lushington's Reasons for the Opinion given by him in preceding paper. Pages 35 and 36 of Blue Book.

---

NOTE.—On the Topographical Map annexed to our Report, Dr. Lushington's line can be easily laid down.

It is already partly done on the western portion, but the dotted line is much too faint. The tangential lines and meridians seem to have puzzled the draftsman.

WILLIAM ROBINSON,
Capt. Royal Engineers, Br.-Major.

*June* 14, 1852.

* To be given in Vol. IV. of this work.—ED.

# PAPER II.

# REMARKS

ON THE

# MILITARY OPERATIONS IN NEW ZEALAND.

BY CAPT. COLLINSON, ROYAL ENGINEERS.

## CONTENTS.

### PART I.—GENERAL DESCRIPTION.

| | Page |
|---|---|
| Introduction | 7 |
| Section I.—General Physical Description | 9 |
| II.—Native Population | 10 |
| III.—British Population, and Description of the Six Settlements | 16 |
| IV.—Government and Land | 22 |
| V.—Climate and Productions | 27 |
| VI.—Communication and Harbours | 31 |
| VII.—Defences | 39 |
| VIII.—Geographical Advantages | 41 |
| IX.—Recapitulation and Statistics | 42 |

### PART II.—NORTHERN CAMPAIGNS.

| | |
|---|---|
| Section I.—General History to 1844 | 44 |
| II.—Tauranga | 47 |
| III.—Wairau | 50 |
| IV.—Kororarika | 52 |
| V.—Okaihu | 54 |
| VI.—Ohaiawai | 58 |
| VII.—Ruapekapeka | 65 |

# PART I.

## INTRODUCTION.

THIS paper is intended to be a short connected account of all the military operations that have occurred in New Zealand from the commencement of the colony. It is brought under the notice of the officers of the corps, in order that in the case of any future disturbances in that colony, they may have an opportunity of referring to the peculiar difficulties and wants which have occurred in previous wars, they being such as are likely to occur in all wars of regular troops against savages. INTRODUCTION.

It is a compilation from some of the many books that have been published about New Zealand, and from some private sources, and from three years' personal experience, from 1846 to 1850.

A short description of the colony is prefixed, which is partly necessary for the clear understanding of the various operations. It is longer than necessary for that object alone; but it is hoped that it will serve as a general description of the colony, to which officers can refer for some general ideas about it when they are called upon to serve there.

It is also hoped that it may possibly assist officers desiring to compile such general descriptions of other places, as several papers in the corps' volumes have assisted the compiler of this. Such short descriptions of all our colonies would form a very useful addition to the corps' book. And officers of engineers have got more opportunities than any other people of collecting such information.

It is with great diffidence that I presume to make any criticisms upon the performances of officers so much my seniors in rank, age, and service; there are no doubt local circumstances with which they alone are acquainted, which would explain such few things as seem to the reader of the accounts to be mistakes. I am aware also of the difference between considering these things quietly in England, and enacting them in New Zealand. And I hope it will be found (or if it is not I hope it will be understood), that it is my desire, not to comment upon what might have been done at the time, but rather to bring forward the great wants and deficiencies that were felt in the various campaigns, with the hope that they may be observed and remedied by those in power before another disturbance breaks out, when it will be too late.

INTRODUCTION.

*List of the books, &c., from which this paper has been compiled.*

Parliamentary Blue Books, 1845-51, which I have been allowed to examine in the Colonial Office.

Official dispatches and papers from New Zealand in the Office of the Inspector General of Fortifications, which the I. G. F. has been kind enough to allow me to examine for this compilation.

Mr. Martin's British Colonies. Edition 1851.

Mr. Wakefield's Adventures and Handbook of New Zealand. 1845-48.

Bishop Selwyn's Journal—Annals of the Colonial Church—1844-49.

Power's Sketches in New Zealand. 1850.

Fox's Six Colonies of New Zealand. 1851.

The local papers of New Zealand. 1845-51.

Col. Despard's Narrative, North Campaign. U. S. Mag., 1846-7.

Terry's New Zealand, 1842.

Lieutenant Balneavis, 58th Regiment, has also given me very great assistance, both with his private journal (he served in all the campaigns from 1845 to 1848), and other documents that he has collected from the 58th Regiment and from other sources in New Zealand.

I have also been very much assisted by other officers of the 58th, and by Captain Henderson, R.A., who served there in 1846-7-8, and by Lieutenant Servantes (late of the 6th Regiment), who served in New Zealand in 1846-7-8, as interpreter to the forces.

The list of harbours has been examined by W. Evans, Esq., R.N., master and assistant-surveyor of H.M.S. "Acheron," during her surveys in New Zealand: he has had the kindness to correct it and add several notes to it. If, therefore, any benefit or instruction is derived from this paper, thanks must be given to these gentlemen who have so materially assisted in its compilation.

The General Map of New Zealand is the latest edition of that published by Arrowsmith, corrected from the surveys of Captain Stokes, R.N., in H.M.S. "Acheron," during 1848-9, '50, '51. He surveyed all the principal harbours and a great part of the coast line. The large plans of the Bay of Islands, Wellington, and Wanganui, are from the New Zealand Company's maps and the colonial maps, which I was allowed to copy and make use of for the office of the I. G. F. during the time I was employed in New Zealand.

T. B. COLLINSON,
Capt. R.E.

*January* 1, 1853.

## GENERAL DESCRIPTION OF NEW ZEALAND.

1. GENERAL PHYSICAL DESCRIPTION.

### SECT. I.—GENERAL PHYSICAL DESCRIPTION.

The colony of New Zealand * (according to the charter of 1840), includes that group of islands lying together in the South Pacific, about 1000 miles east of Australia, and consisting of two large islands and one small one, being called *New Ulster*, or North Island; *New Munster*, or Middle Island; and *New Leinster*, or Stewart's or South Island: and of the small group lying about 200 miles east of them, called the *Chatham Islands*. The two large islands lie about north and south, and are both long and narrow islands; *New Ulster* being about 500 miles long, and 100 average breadth; and *New Munster*, about 550 miles long, and 150 average breadth; *New Leinster* is in the shape of a triangle, of about forty miles side. The whole containing together about 123,500 square miles, † or 78,000,000 acres, ‡ being nearly the same area as Great Britain and Ireland together.

The boundaries of the Colony, according to the Act of Parliament, 1852, are from 33° to 50° south latitude, and 162° to 173° west longitude.

In *New Ulster*, or North Island, the northernmost point is called *North Cape;* one-third of the way southward, at the narrowest isthmus of the island, is *Auckland;* at the extreme point in Cook's Straits is *Wellington;* between Auckland and Wellington the most projecting cape on the west coast is called *Cape Egmont;* and the most projecting cape on the east coast is called *East Cape. Cook's Straits* divides the north island from the middle island; Foveaux Straits divides the middle and south islands. In *New Munster*, or Middle Island, at the extreme south-west point, is *Dusky Bay;* and on the east coast, at about one-third down from Cook's Straits is *Banks' Peninsula* (*Canterbury*)*;* and two-thirds down the same coast is *Otago.*

The physical features of the islands are generally speaking mountainous, the mountains being high and volcanic, and not running in long regular ranges as in England, but in very steep abrupt ridges, running in all irregular directions, and frequently ending in conical mountains of 5000 to 10,000 feet, between which ridges are long flat valleys, more or less narrow; the hills being generally covered with forest, and the flat valleys grass and fern land. This is the general character of the country in all New Zealand.

From the North Cape there is a range of these hills running through the centre of the island to Auckland, and filling by its branch ranges almost the whole space to the coast on each side, and generally covered with thick forest of Kauri pine, with few flat valleys, and little level or open country.

About Auckland the country is lower and more open; and the whole of the valleys of the rivers Thames and Waikato, from Auckland to Taupo Lake in the centre, consist of fine open country, tolerably level, and covered with grass or fern, with a range of hills on each coast.

From Taupo Lake there is a range 5000 to 10,000 feet high, running to Wellington, and another similar range running to East Cape, and filling almost the whole of that projecting land with wooded mountains. Between East Cape and

* See Arrowsmith's map, 1851, p. 5. † Martin's Cols. says 95,000.
‡ Handbook, 1848.

1. General Physical Description.

Wellington is Hawke's Bay, and about this bay are large level grassy plains, and, going southward, there is a broad, level, grassy valley extending to the sea in Palliser Bay, east of Wellington.

From Taupo Lake another range of steep wooded mountains runs towards Cape Egmont, falling as it approaches the coast, but ending in the volcanic cone of Mount Egmont, 9000 feet high. All round Cape Egmont and down the shore of Cook's Straits to Wellington, between the hills and the coast, is a belt of flat grassy and wooded land.

The south shore of Cook's Straits is filled from sea to sea with the same steep wooded ridges, 2000 to 5000 feet high, with long, narrow, flat grassy valleys between; and the range continues down the Middle Island, near to the west coast, as far as Dusky Bay. Between it and the East coast are broad valleys and plains of level grassy land.

There are no very large navigable rivers in New Zealand, but a great number of small rivers like the Tyne in Northumberland, into which small vessels can enter; and a considerable number of harbours round the coast, some of which are very good. It is a peculiar advantage of New Zealand, that being long, narrow, mountainous islands, there are great means of access to the interior through the number of small harbours and rivers on its great extent of coast line.

## Sect. II.—Native Population.

2. Native Population.

The natives are of the same race that inhabit the other islands in the Pacific, being a perfectly different and much superior race to those in Australia. The Polynesian native is supposed to be descended from the Malay; the Australian native is of the negro race.

According to their own traditions, and to the best accounts that have been made out concerning them by the missionaries, their ancestors came from some of the Pacific islands to the north-east of New Zealand in canoes, about 500 years ago; settled in the northern island, and spread over it and populated it as far south as Cook's Straits, and even to the extreme south. Their manner of life, which has been handed down to them from their ancestors, has been that of cultivation of the soil, and very different from the roving savage of Australia, or the hunter of North America. It has no doubt originated from there being no space to hunt over, and no game to kill. Their peculiar mode of life is important to be recollected, in considering the causes of disputes between the British and the natives. They live in small villages, 100 to 500 in each, along the sea-coast and up the principal rivers; each family having its hut railed off in the village, and the whole being inclosed in a strong palisade arranged for defence. The cultivations are cleared out among the woods in the neighbourhood, being a few acres to each family; and the huts and cultivations descend from generation to generation, both by male and female line. Every man and woman inheriting such a property is a free independent person in the tribe; but those who are more lineally descended from their ancient leaders form a kind of hereditary aristocracy, and generally have some family dependants, or slaves taken in battle, to work for them. And the people of one village, and of several villages in one district, are generally descendants of one original family, and look up to some one head branch of the family as their leader, forming *a tribe*, with whom this representative of the elder branch has the chief voice, each man having also his independent voice and independent right to his property.

2. NATIVE POPULATION.

The husband has a right over the inheritance of his wife; hence the intermarriages in the tribe or between two tribes create constant disputes about land, neither the boundaries nor the rights of property being very clearly defined.

Their huts consist of little more than a common ridge roof, about 20 feet long and 10 broad, standing on the ground; the walls being only a few inches high. They are made of rough poles thatched with long grass, or bark, and neatly lined inside with plaited reeds or grass. But there is only one opening, and the fire (of wood) is on the floor in the centre. The chief's house being generally the largest, the village crowds in on winter nights to sleep all together for warmth.

They wear nothing but mats made of flax, which the women dress and weave into a coarse cloth: they wear them hanging from the shoulders to the ground, both men and women, with generally a smaller mat tied round the waist. No head dress, and nothing on the feet. The men tattoo all the face, and sometimes the posteriors, and the women tattoo the lips and chin.

They live chiefly on potatoes (the originals of which were left by Captain Cook), and sweet potatoes, and *taro* and pumpkin, and fish, and sometimes on the wild pigs (which, having been left by Captain Cook, have become wild in the woods). All the vegetables they cultivate themselves,—to which they have lately added wheat and maize. Thus their principal occupation is cultivating their little gardens in the woods, and fishing; the women taking part in the former, and also doing the cooking and other drudgery of the village. They are a very dirty race; scarcely ever washing. They wear the same mats day and night for years—just squatting on the ground in front of the hut to eat, and lying on mats (made of raw flax leaf plaited) to sleep. They use pumpkins for drinking bottles and dishes; shells for knives; and (since they became acquainted with Europeans) both men and women have taken to smoke tobacco constantly—but very little to drink spirits.

They are, even now, sometimes so hard put to it for food, as to eat fern root prepared in cakes; probably this want of food originated the practice of cannibalism amongst them. They are of ordinary stature, well built, and active (for savages).

These are the habits of the New Zealander as they were before British colonisation; now, European customs, clothes, houses, and food, are springing up amongst them, not only in the neighbourhood of the settlements, but all over the country. The amount of civilisation which is being produced among them, is a disputed question; * but there is no doubt that there has been a great and very general change made in their habits. They have very generally learned to read and write, to build better huts, to cultivate wheat and other European fruits, to attend a place of divine worship and schools. They have left off much of their fighting propensities and the practice of cannibalism. Now this improvement is due partly to the colonisation by the British Government, but chiefly to the missionaries.

The missionaries commenced in 1815,† when there were only a few English whalers about the islands, and when they were a few men among hosts of cannibals, and they gradually spread over the whole islands, living alone with their wives and families in different parts among the natives: since the colonisation, they have been countenanced and supported by the British Government, and have increased their operations with still more effect, and the Government have

* Fox, Six Cols. † Terry, 1842.

2. NATIVE POPULATION.

granted money for educating the natives, and built hospitals for them at the settlements, and established magistrates, both European and native, for administering British law among them, modified to suit their character. On the other hand, the natives will cheat and rob when inclination and opportunity offer; they are very indolent and very prone to fall back from civilisation; easily excited, and when excited, not to be controlled even by their own wants, much less by their reason; but not capable of persevering for any length of time in anything.

In short, they are still savages, and are therefore to be treated as all savages should be—with a strong hand and with kindness.* And being perhaps the most intelligent savages in the world, are to be treated with more consideration than any others.

The missionaries have all along endeavoured to prop up the natives into the civilised ranks.† Before the colonisation they desired to make them an independent nation, as their fellow-missionaries had done in Tahiti and the Sandwich Islands; since that they have always tried to place them on the same level with the European colonists; but it is impossible, the natives are not capable of being fully civilised; the proof of it is that they are decreasing still. In *fifty years* there will scarcely be one New Zealand native alive.‡ All that can be done is to let them die out as quietly as possible.

Dr. Shortland (1851) thinks the natives are not decreasing, but that they will continue to exist as a race; but considering the great disproportion of the sexes, I have followed the opinion of Bishop Selwyn, which is the general one in New Zealand.

There are about 90,000 natives in the islands; of these, all but 3000 are in the North Island.

The following estimate of the native population has been supplied to me by Mr. W. Servantes (late 6th Regiment, and interpreter to the forces in New Zealand), who also marked the localities of the tribes on Arrowsmith's map, p. 5.

* Nelson Petition, 1845. † Parl. Blue Book, 1845.
‡ Bishop Selwyn. Fox, Six Cols.

2. NATIVE POPULATION.

## APPROXIMATE CENSUS

*Of the Native Population of New Zealand, by* W. SERVANTES, Esq., *late Interpreter to the Forces.*

N.B.—The great subdivisions and greatest chiefs are printed in Roman capitals. The divisions and chiefs of next importance are printed in italics.

| Tribe. | Locality. | Chiefs. | Population. |
|---|---|---|---|
| *Te Rarawa* | *North Cape, Kaitaia* | Papahia<br>Nopera | 2800 |
| NGAPUHI | *Bay of I. and Hokianga* | | |
| Ngati Tautahi | Kaikohe | Pairama | 800 |
| Ngatimanu | Tokerau | *Pomare* | 400 |
| Ngatihine | Kawakawa | *Kawiti* | 300 |
| Uriongaonga | Do. | Pukututu | 700 |
| Te Mahurehure | Hokianga | Moses Tawhai | 700 |
| Ngatihao | Hokianga | *Waka Nene*<br>Patuone | 400 |
| Other sub-tribes | — — | Rewa, Moka, Hongi, Moehau, Rangatira | 6200 |
| | | Total Ngapuhi . . | 9500 |
| *Ngatiwhatua* | *Auckland*<br>*Kaipara* | Kawau<br>Paikea, Te Tinana | 1200 |
| WAIKATO | *Waikato River* | | |
| Ngatimahuta | Lower Waikato and Manukau | TE WHEROWHERO | 400 |
| Ngatihaua | Matamata and Upper Waikato | William Thompson | 800 |
| Ngatimaniapoto | Kawia, Mokau | Taonui, Waru, Pungarehu, Wetere, Pakaru, Poutama | 5500 |
| Ngatipaoa | Hauraki, R. Thames | *Taraia*, Hauauru, Kahukote, Ruinga, Hou | 2700 |
| Other sub-tribes | — — | Kiwi, Katipa, Mokorou, *Awaitaia* (Wm. Naylor), Uira | 6600 |
| | | Total Waikato . . | 15000 |
| *Ngatiawa* (No. 1) | *Tauranga* | Tupaea, Taipari | 2400 |
| *Ngatiwakauae* | *Rotorua* | Tohi, Tongoroa | 8000 |

2.
NATIVE POPULATION.

| Tribe. | Locality. | Chiefs. | Population. |
|---|---|---|---|
| *Ngatiawa* (No. 2) | *Opotiki* | Hikaro, Punu, Rangimatanuku | 7000 |
| NGATIKAHUHUNU | *Hawke's Bay* and *Wairarapa* | | |
| *Ngatiporou* | East Cape and Turanga | KANI A TAKERAU, Ratau | 10,000 |
| *Ngatikahuhunu* | Hawke's Bay and Wairarapa | *Hapuku,* Apatu o te rangi | 2,000 |
| | | Total Ngatikahuhunu | 12,000 |
| *Taupo* | *Taupo* | HEUHEU (Iwikau) *Herekeikei* | 1500 |
| *Ngatiawa* (No. 3) | *New Plymouth,* Port Nicholson, Q. Charlotte Sound, Blind Bay | *Reretawangawanga* (dead), Wm. King | 7000 |
| *Taranaki* | *Taranaki* and *Port Nicholson* | | 2000 |
| *Ngatiruanui* | *Cape Egmont* | Anataua | 3000 |
| *Wanganui* | *R. Wanganui* up to its source | Turoa, Mamaku, Hori King | 7000 |
| *Ngatiraukawa* Including remnants of original tribes | *R. Manewatu* (originally from Waikato) | *Te Rauperaha* (dead), *Watanui,* Matia, Puke, Ahu, Hakaraia, Taratoa | 3500 |
| *Ngatitoa* | *Porirua* and Cloudy Bay (originally from Waikato) | *Puaha,* Kanae (sons of *Pehi*) Rangihaiata, Moses | 1000 |
| *Ngaitahu* | Middle Island | Taiaroa | 3700 |
| | | Total population, about | 90,000* |

* Sir G. Grey (1849) estimates the total population at 120,000, in which estimate Dr. Shortland (S. Districts of New Zealand, 1851) agrees. These are two good authorities; but the Bishop's estimate was about 60,000.

The natives in each of these districts may be considered as allied among each other, and likely to join together in case of war against another district; but still divided into small tribes frequently at variance with each other, and frequently joining those of other districts. There are many chiefs in each district, and some whose names are a tower of strength throughout the whole country; as *Te Wherowhero* in the Waikato district; *Ranghiheata* in the Cook's Straits district; *Hapuku* in the Hawke's Bay district; *Kawiti* in the north. 2. NATIVE POPULATION.

The celebrated *Heki* (now dead) was a chief in the north district, but not of great importance.

*Te Heu Heu* (now dead) was a chief of Taupo, and the greatest in all New Zealand.

*Te Rauperaha* (now dead) was a chief of Cook's Straits district, and of third rank in New Zealand after *Heu Heu* and *Wherowhero*.

In Captain Cook's time, his estimate of the population was double the above estimate.* They have decreased partly by war, and partly by their savage customs and habits, and partly by the semi-transition into civilisation. In 1825, the northern tribes, under *Hongi*, obtained fire-arms, and made an inroad upon the Auckland and Waikato tribes, who in their turn made inroad upon Cape Egmont natives, who in their turn made inroad upon the Cook's Straits natives, who were driven into the Middle Island, and some even to the Chatham Islands. This tide of conquest has very much complicated the question of property, as, since the Colonisation, some of the exiles have returned to their original districts, and set up a counter claim to that of the conquerors, which their own customs obliged them to acknowledge.

All the natives in New Zealand fight with fire-arms now, having been supplied with them by traders previous to the Colonisation; they have been supplied with arms and ammunition since that by private traders, notwithstanding the laws to the contrary. They take considerable care of their arms, and keep their ammunition in bottles and kegs underground. They make cartridges of a large size, and wear small leather pouches, which they also get from traders.

† Their ancient religion was the worship of nature, deifying various animals and celebrated heroes; they had hereditary priests, but no images or temples. They were very superstitious about the dead, and afraid of the dark. Now they are nominally converted to Christianity; chiefly Protestants, very few Roman Catholics.

Their language, like that of all the Pacific islands, is supposed to be derived from the Malay. ‡ They use more consonants than the Tahitian or Sandwich islander. They pronounce the letters *r* and *h*, instead of *l* and *s*.

The missionaries have reduced the language to an alphabet and a grammar, which are now used by all the natives; so that the ancient language has been altered, and is not understood by the rising generation. It is a simple language and easily learnt. They are teaching the natives English, but the difficulty is so great, that the native language will still be the medium of communication for some years at least. In the Missionaries' alphabet the vowels are pronounced not according to the English, but according to the Continental pronunciation, which should be borne in mind in reading *Maori*, which is their term for their own nation, in contradistinction to *Pakeha* the foreigner. The native words to be so pronounced are printed in italics.

* Fox, Six Cols. † Handbook. Terry. Rev. R. Taylor, missionary.
‡ Rev. John Williams, South Sea Mission.

2. NATIVE POPULATION.

*Taua* is their term for a war party. *Ware* is their term for a house.

I strongly recommend it to every officer, likely to remain several years in the colony, to learn the language. A little knowledge of it gives a very great influence among them.

The character of the New Zealander for intelligence has not been at all overrated in my opinion. They have a wonderful quickness of apprehension, and good memory, and a ready wit not easily put down. They are more energetic than the soft savage of Tahiti; and probably from their being reduced to cultivation for food, they are most remarkably given to commerce and trading of all kinds.

This character does not agree very well with that of a warlike cannibal; and I think that their character for war has been rather exaggerated. Their own native wars show much more of strategy—the long-watching ambush, the occasional skirmish, and the frequent truces—than the incessant, unrelenting pursuit of the true savage warrior. And in their wars with the British, as we shall find, they owe their escapes to the character of their country rather than to their own defence; and they did not make the most of the peculiar character of their country.

3. BRITISH POPULATION.

## SECT. III.—BRITISH POPULATION, AND DESCRIPTION OF THE SIX SETTLEMENTS.

The present position of the British population is this :—

There are first the Missionaries, who commenced in 1815, and are now scattered all over the islands, living among the natives.

Then the Whalers who commenced, before the Missionaries, to frequent the coast in ships, and gradually established parties on shore, who lived permanently among the natives, marrying native women, holding their own by the force of union, and employing themselves in whaling in boats from the shore. They were all round the islands, but chiefly at the Bay of Islands, and in Cook's Straits, and Foveaux Straits. Their occupation of whaling is now nearly gone, but they are still living there upon the produce of the land, which the natives allow them to cultivate in right of their wives. There were about 1000 of them in 1839.*

Then there are *Six separate British Settlements*,† all on the coast: namely,

1. *Auckland.* Founded 1840.
2. *Wellington* (including Wanganui). 1840.
3. *Nelson.* 1842.
4. *New Plymouth.* 1841.
5. *Otago.* 1848.
6. *Canterbury.* 1850.

AUCKLAND.

AUCKLAND was founded by the British‡ Government. In 1840, Captain Hobson was sent out to obtain possession of the islands. He first of all founded his capital at the Bay of Islands, but changed it the same year to Auckland; and purchased land there from the natives, and from Englishmen who had bought it from the natives previously, and resold it to settlers from Australia and England. There are about 100,000 acres near Auckland, thus in possession of British colonists. The town is on the Waitemata river, which runs into Houraki Gulf on the east coast; one of the great advantages of this situation is the *easy access of the harbour;* § vessels can anchor in the gulf waiting to go in. The harbour is rather an estuary than a river, and is about three-quarters ‖ of a mile wide, deep enough for any

* Fox, Six Cols. † Martin's Cols. ‡ Terry.
§ See p. 37 for description of harbours. ‖ Martin's Cols.

3. BRITISH POPULATION. — AUCKLAND

vessels; a strong tide and perpetual strong winds up and down the river. The banks are clay cliffs 50 feet high, at the back of which is a bare undulating country like a moor; the town is in a little valley on the south bank, about three miles from the mouth, and has the appearance of an English fishing town; it contains about 4000 British inhabitants.* Their occupation is exporting copper ore, which is worked at *Kawau* in the Houraki Gulf; and pine timber, which is obtained from all the neighbouring coast, and some wool and native flax, and vegetables; but they are chiefly supported by the expenditure of the Government. The Governor-in-Chief and Commander of H.M. troops resided there up till 1851, and up to that time there were 500 troops in barracks. The houses are chiefly built of wood, but bricks are made on the spot. There is a public wharf building, without which the landing is very bad. The soil about Auckland is tolerably fertile, clay covered with small shrub and fern; not expensive to bring under cultivation. Several thousand acres have now been brought under cultivation; but there is not much stock farming. Living is cheaper than in England, and wages higher. There is very excellent water communication by means of numerous branches of the Estuary to the neighbouring country; and across the isthmus seven miles, is the harbour of *Manukau*† on the west coast, into which all vessels can enter, though it is not very accessible, but which will be an excellent point of communication for steamers from Australia.‡ There are great facilities for establishing water communication between Auckland and Manukau harbour and the Waikato river, which would open water communication with the whole valley of the Thames and Waikato rivers; which valley contains a great extent of level fertile land. There are tolerable cart-roads for a few miles out of the town in various directions. Natives live near the town; for the Government in purchasing land have always reserved the villages and cultivations of the natives for themselves, besides paying them for the remainder.

There are some off-shoot settlements from Auckland.

*Kororarika* in the Bay of Islands, established by the Missionaries, who have purchased the land from the natives; but it has been nearly deserted since the war with the natives in 1845, when it was burnt.

There are also settlers established in different parts by themselves among the natives; at the rivers *Hokianga* and *Kaipara* on the west coast, and in *Houraki* Gulf, chiefly for cutting timber. They have either bought land from the natives before the Colonisation, or from the Government since.

WELLINGTON.

WELLINGTON § was founded in 1840 by the New Zealand Company, who sent out an expedition in 1839 under Colonel Wakefield, who purchased large tracts of land from the natives about Cook's Straits. But the purchase was not properly made, and some of the natives repudiated the sale, and the disputes and wars went on till 1848, when they were fairly settled, and the Company got peaceable and legal possession of several blocks of land; among which was one about Wellington of 280,000 acres.‖ The Company is now defunct, and all their possessions have reverted to the Crown by agreement; so that the circumstances of all the Company's settlements (as far as land is concerned) are the same as those of Auckland.

¶ The harbour of Wellington is called *Port Nicholson;* it is in the narrows of Cook's Straits on the north side; *it is difficult of access,* owing to the narrow

* B. B. 1848. † See p. 37. ‡ Capt. Fitzroy's pamphlet, 1847.
§ Terry, 1842. Handbook, 1848. Fox, Six Cols. Martin's Cols.
‖ Crown grant, 1848. ¶ See p. 37.

3. British Population. — Wellington.

entrance running parallel to the Straits, and the constant strong winds that blow up and down the Straits. It was selected from being the only harbour in the north island south of Hawke's Bay. There are fine harbours on the other side of Cook's Straits, especially Queen Charlotte's Sound, where Captain Cook always lay, and which, in my opinion, would have been a better site for the first and great settlement of the Company. Colonel Wakefield visited it, but it was thought at the time that there was more available land about Port Nicholson;* this was not proved to be the case; the whole country on the Wellington side, from *Palliser Bay* to *Kaputi Island* in Cook's Straits, is filled with a mass of wooded mountains, rising to a height of 1000 feet. Port Nicholson is a basin surrounded by these hills, through which roads must be made to reach available land in any direction: nevertheless, as the town has been placed here, it will probably be the capital of New Zealand for many years; as it is evident, from its central position in Cook's Straits between all the settlements in both islands, that it is more suited for the seat of central government than Auckland, or any other present settlement. The harbour is safe when you get in, and deep enough for any vessels; it is about five miles square. The town is in a cove in the south-west corner, a very good site, tolerably level land, backed by the steep hills, some grassy, but most of them covered with thick impenetrable forest. It contains about 4000 inhabitants,† being about equal to Auckland, but they are nearly all real English settlers who came out direct under the Company's auspices, but from the disturbances were never able to occupy their land, and were compelled to stay in the town; and would have gone away altogether, but for the great expenditure of the British Government consequent on the wars, which has given them capital, and which capital they are now able to expend upon the land. The Company sold a great deal of land among the hills about Port Nicholson, and the settlers have cleared and cultivated in some of the wooded valleys; *the Hutt valley* is the largest of these, and is at the head of Port Nicholson; but it only contains about 10,000 acres of good land, and that is all forest. The chief business of Wellington is the export of wool to England. In Wairarapa valley to Hawke's Bay, and on the north-west coast to Cape Egmont, are open grassy tracts good for grazing, and the Colonists are occupying these with cattle and sheep brought from Australia, leasing the land from the Government, or from the natives; this latter practice is illegal, and is very dangerous.

The houses are chiefly built of wood, and although bricks are made in abundance, they are still built partially of wood in consequence of the slight shocks of earthquakes which sometimes occur.

The Lieutenant-Governor of the Southern Provinces resides in Wellington; and there are 500 troops in the town and neighbourhood, in barracks, but there are no defences either against external or internal enemies; only a few armed police and no militia, not even pensioners; and no additional military works have been ordered up to 1852.

Two cart-roads are making by the Government from Wellington through the hills; one towards *Wairarapa* valley, and one towards the north-west coast and *Wanganui;* each will be about forty miles long before it reaches the pasture land; the former is now about half finished, the latter completely finished. There is no passage off these roads for man, animal, or carriage, except by a few short by-roads.

Natives live in and about Wellington upon the reserves which were made for them by the Company and Government at the time of concluding the purchase.

* First Report N. Z. C. † B. B. 1848.

The offshoot settlements from Wellington are *Wanganui* and *Rangitiki*, both together, at about 100 miles along the north-west coast towards Cape Egmont. *Wanganui* (or *Petre* as it is called by the English) was established by the Company at the same time as Wellington, as a part of it; and by the same bad management of the purchase, and ill conduct of the natives, the settlers were prevented from occupying their lands, and obliged to live in the little town, till 1848. The town is four miles from the mouth of the Wanganui river, which is navigable to that distance for all craft not drawing more than 14 feet of water; and is on the right bank. The country lies in plateaus at different levels above the sea. These table-lands extend all along the coast, between the mountains and the sea from near Wellington to round Cape Egmont. From Cape Egmont to *Wanganui* they are 200 to 300 feet above the sea; at *Wanganui* they turn inland; and a lower plateau begins about 20 feet above the sea. Their character is the same everywhere, covered with fern, flax, and grass, with clumps of thick pine brush here and there, and intersected by streams in all directions; in the high plateaus the streams form deep ravines; the valley of the *Wanganui* is a plateau half a mile broad, and about 30 feet above the sea, backed by the higher plateaus which end in steep scarps as if they had been cut by the action of water. I have described this country more fully because *this plateau prairie character is common to all the large valleys and plains in New Zealand.* Twenty miles up the *Wanganui* the country becomes broken into high narrow ridges covered with timber; but in fact the plateaus are with difficulty passable for man and horse, and impracticable for regular troops except by the footpaths.

3. BRITISH POPULATION.

WANGANUI.

There are about 1000 British colonists at *Wanganui* and *Rangitiki*, occupied in stock farming. There is a strong military post at the town garrisoned by 200 men: and the natives live in their villages all about the rivers. The land purchased by the Company at these two places is altogether about 200,000 acres.

The communication with Wellington is either by water in decked vessels of about thirty tons, common all round the New Zealand coast; or by land along the coast, which is hard sand the whole way to opposite *Kaputi* Island, where the cart-road from Wellington comes out; the only difficulty being the numerous small tidal rivers.

There are whalers squatted all down the coast, and settlers keeping stock on the native land, paying rent to the natives. In the *Wairarapa* valley there are some 100 English, with many thousand sheep and cattle thus squatting on native lands.*

The Government are continuing to extend their territory by purchasing land from the natives, on the west coast and at Hawke's Bay: and these districts are gradually filling with settlers and their cattle and sheep, intermixed with the few natives residing on the reserves always made for them at the time of purchasing the land.

NEW PLYMOUTH.

† NEW PLYMOUTH was founded in 1841 by a Company from Plymouth in England under the auspices of the New Zealand Company. But there were just the same mistakes and disputes about the land, and the Company got pessession of only 4000 or 5000 acres of their original block; they afterwards purchased a separate block of 30,000 acres to the south of the other.

‡ There is no harbour, only a roadstead, where vessels cannot anchor in northerly weather. There is only a small river, the *Waitera*, into which small craft drawing not more than 12 feet of water can enter.

* Statistics, New Munster, 1848. † Emigrant's Guide, and Martin's Cols. ‡ See p. 37.

3. BRITISH POPULATION. — NEW PLYMOUTH.

The country is a continuation of the fern and grass plateaus, watered by many streams, and backed by broken forest country: it is sheltered from the south by Mount Egmont, and the soil is very rich. Indeed the fertility of the level fern plains of *Taranaki* have caused it to be called "The Garden of New Zealand," by the natives themselves. There are about 1200 English settlers,* chiefly farmers, cultivating the soil close about the town, which is on the coast. They already export wheat and flour. There are numerous natives all about the settlement, but there have never been any troops there, as there has never been any open hostility on the part of the natives: though they have always been disposed to be quarrelsome.

NELSON.

NELSON was founded by the New Zealand Company in 1842.† It is situated at the head of Blind Bay, on the south side of Cook's Straits. The original purchase included the whole of the north end of the island above a line drawn across somewhere about Lookers-on Bay; but from the disputes with the same tribe of natives as disputed at Wellington, they only got possession of the land round the shores of Blind Bay, until 1848, when they obtained legal and peaceable possession of all the remainder of the block. The settlers therefore have chiefly occupied the country about Blind Bay, and as the hostile natives never came to that part, they have been able to make greater progress in cultivation than any other settlement. They got the advantages of the war expenditure without so much of the misfortunes.

The whole of the north end of the middle island, from Cape Foulwind to Lookers-on Bay, is traversed by long narrow ranges of mountains running to every promontory, and from 1000 to 5000 feet high; but there is not so much forest on them; many of the lower ranges are covered with grass, and make good pasture land; and there are numerous long flat valleys containing good agricultural land. One of the largest of these valleys is *The Wairau*, running into Cloudy Bay; this valley and the adjacent country is now occupied by some hundred settlers from Nelson with thousands of sheep and cattle; their port is a harbour at the head of Queen Charlotte's Sound; the disadvantage of this Sound is its great depth, being sixty fathoms in the centre; but it is safe and *very accessible.* It only requires ten miles of road (which is in course of construction I believe) to communicate with the great valleys above mentioned, and which, in my opinion, will make it one of the most advantageous, as it is one of the most central, settlements in all New Zealand.

At the head of Blind Bay is another good large valley called *The Waimea*, and four miles east of it is a little harbour where the town of NELSON is placed. The harbour is formed by a natural breakwater, and is very small with a narrow entrance. A man-of-war corvette, and steamer, have both been in it. There are 4000‡ English settlers in Nelson, and about Blind Bay. They export wheat, barley, and timber, and wool. They cultivate in the valleys, and keep stock on the hills. There is coal found in Massacre Bay in Blind Bay; it crops out close to the sea; and fossiliferous limestone and sandstone; from the opinion of coal owners in the north of England it appears probable that this coal will prove, when excavated, equal to the Newcastle coal of New South Wales. There is a small harbour close to the coal. There is a cart-road from Nelson to the Waimea valley, but beyond that only horse tracks, and those very difficult. The communication inland to the *Wairau* valley is by a bad horse path.

* Em. Guide. † Em. Guide and Martin's Cols.
‡ Report of Mr. Bell, agent N. Z. Co. 1849.

One of the great advantages of *Nelson Haven* is the rise of tide, which is 12 feet, being greater than in any other part of New Zealand. Another advantage of Nelson is in the climate, which is calm and sunny, being out of range of the Cook's Straits gales.

3. BRITISH POPULATION. — NELSON.

There are very few resident natives in this part of the Middle Island, or in any part of it; they are the remnants of the tribes who were exterminated by the more northern tribes from about New Plymouth. The conquering tribes live on the north side of Cook's Straits, and visit occasionally the south side, being the same who disputed the whole land question in which the New Zealand Company were concerned.

OTAGO. OTAGO, also under the auspices of the New Zealand Company, was founded in 1848 by a Scotch company, and was intended to forward the emigration of persons belonging to the Free Church of Scotland. They obtained a large block of land, from the New Zealand Company; who, through the Government, have puchased in the course of 1847-8-9 from the natives the whole of the middle island, north of a line drawn across somewhere about Molyneux River; and there has been no trouble with the natives, and no disputes about land. The few natives who inhabit these parts live peaceably on their reserved lands.

There are about 1200 English settlers * occupied chiefly in stock farming, most of whom have migrated direct from Scotland. The capital town, situated in the harbour, is *Dunedin.*

The harbour is safe, but *difficult of access.*† Dunedin is at the very head of it, seven miles above the anchorage for vessels. The country about it is of the same wooded hilly character as about Wellington, though not quite so mountainous; but to the southward are some large valleys of the grassy plateau character, of which Molyneux River is the largest. There is only a horse-path at present from Dunedin to these districts.

CANTERBURY. CANTERBURY was founded in 1850 by an English company in London, also under the auspices of the New Zealand Company, for the purpose of promoting the emigration of persons belonging to the Church of England. They obtained a block of about 2,000,000 acres from the Company, situated at *Banks' Peninsula,* about 200 miles south of Cook's Straits. The whole of this peninsula is a mass of mountains 1000 feet high, indented with long narrow bays; but behind it lies one of the largest prairie plateaus of New Zealand, extending about 100 miles along the coast, and fifty miles back to the mountain backbone of the Middle Island, and almost flat, covered with grass, flax, and fern. The Canterbury Association have selected the harbour on the north side of Banks' Peninsula, and nearest to the plain, as their port; it was called *Port Cooper*, now *Port Victoria.* It is a straight inlet, open to the north-east, *very easy of access.* ‡ There is very little level land about the harbour; but it is only five miles over the hills to the plain, and a cart-road is finished, or nearly so, going over a level of 600 feet.

The rivers from the plain are navigable only for small boats. The Association are selling land at 3*l.* 10*s.* per acre. There are about 3000 (1851) settlers there,‖ who have bought land, or have been brought from England as labourers; they are scattered in different parts of the plain.

As at Otago, there have been no troubles with the few natives living about Banks' Peninsula; the chief difficulty appears to be the want of timber on the plains for firewood and building. This is unusual in New Zealand, and will cause

* Em. Guide. † See p. 37. ‡ See p. 37.
§ Mr. Godley, 1st Letter. ‖ Martin's Cols.

3. British Population. — Canterbury.

this settlement to be expensive for some years to come. There is timber on the mountains, both on the peninsula and on the back range; and the only difficulty in transporting it across the plain appears to be the rivers, and they are small. And there is a coal district in the southern part of the plain. And bricks can be made no doubt anywhere, as the soil is sandy clay and gravel. One of the advantages of this settlement is in the superior arrangements made for the reception of emigrants on their first arrival.

## Sect. IV.—Government and Land.

4. Government and Land.

The *Government* of New Zealand, from the commencement up to 1852, has been conducted by a Governor-in-Chief, appointed by the Crown, and assisted by a council consisting partly of the officers of Government, and partly of persons nominated by the Governor. This has been the form of government since the colonisation in 1840; but in 1847 the colony was divided into two provinces: the Governor-in-Chief residing at Auckland, and governing in the northern province; and a Lieutenant-Governor residing at Wellington, and governing in the south province with the assistance of a similar council;—the two councils together forming a general council for the government of the whole colony under the Governor-in-Chief. All the officers of Government are appointed by the Governor, subject to the confirmation of the Crown; the Crown appoints three judges to try the graver offences; and the Governor appoints magistrates (some of whom are *paid*, and are called resident magistrates) to try small offences.

The Governor and council pass all acts necessary for the government of the colony, which, on receiving the Royal sanction in England, become the laws of the colony; besides which, the laws of Great Britain are in force. The revenue is raised by these laws, and is chiefly obtained from customs duties; and goes to pay the officers of Government and the police, and to make roads and other public works. 12,000*l.* out of the revenue is annually devoted by Act of British Parliament to the Civil List, which is under the control of the Governor; and the sums voted by the British Parliament for New Zealand (which have been about 30,000*l.* a-year since 1845), are also under the control of the Governor.

The councils also pass acts affecting the natives as well as English. British law is by these acts slightly modified, to suit the native character; and some of the chiefs are selected by the Governor to act under the law as magistrates in native cases. But British law or colonial law is in force throughout the whole colony. There is no line of native territory. This, however, is only nominal; for, excepting near the settlements, British law is not, and could not be, enforced among the natives.

There are no convicts, and never have been any, in New Zealand; and the law is preserved in the settlements as well as it is in any part of the British dominions. There are about 50 armed police among the settlements, composed of Europeans and natives, both of whom perform all the duties indiscriminately.

The expense of the British troops (and there are no other) is paid entirely by the British Government. There have been two foot regiments, amounting with Artillery, Sappers, &c., to about 2000 men, in the colony since 1845; and they have cost 180,000*l.* a-year. There have been also 600 pensioners since 1849 located near Auckland, in villages, the expense of whom has been entirely paid by the British Government. *

* I believe this expense has been constituted a debt upon the Colony.

Part of the revenue is appropriated (by the Council) to education both of natives and English, and part to religion, which is divided amongst the heads of the principal religious denominations: the Protestant missionaries are also supported by the London Missionary Society, and the Wesleyan Missionary Society, and the Society for the Propagation of the Gospel. The funds of the latter are given to the English Bishop, and devoted both to the English settlers and the natives. There is a Church of England school, a Wesleyan school, and a Roman Catholic school for children of the better class in Auckland, and parish schools in all the settlements; but the want of means of education is a very great want throughout the whole colony.

4. GOVERNMENT AND LAND.

Excepting in one or two places, where they have been lately established, there are no corporations or county authorities yet in New Zealand; the whole public business, police, gaols, roads, streets, hospitals, &c., being paid out of the general revenue.

In 1852 the British Parliament passed an Act giving a free Constitution to New Zealand. By this Act the government of the colony is to be conducted as follows.—

### THE CONSTITUTION OF 1852.

#### I. GENERAL GOVERNMENT.

To be conducted by a *General Assembly* composed as follows:—

1. *The Governor in Chief* appointed by the Sovereign.

2. *A Legislative Council* composed of 10 members appointed by the Sovereign, and for life.

3. *A House of Representatives* composed of from 24 to 40 members elected for 5 years by certain electors, from electoral districts appointed by the Sovereign.

4. *The Franchise* to include all British male subjects 21 years old (except criminals), and of the following properties; 50*l.* freehold estate, being in possession 6 months before registration; 10*l.* per annum, leasehold estate, being in possession 3 years previous to registration, or for three years to come. 10*l.* per annum householders in towns, and six months' residence. 5*l.* per annum householder in country, and six months' residence.

5. *The powers of the General Assembly* to extend to making all laws for the government of the Colony with the following restrictions only:

No laws to be contrary to the laws of England.

No duties to be laid on supplies for the imperial forces.

No duties to be inconsistent with British treaties with foreign states.

The custom accounts to be under the management of Her Majesty's Treasury.

A civil list of 16,000*l.* per annum to be provided for without power of alteration, except with the sanction of the Sovereign: and the expense of collecting the revenue and payments to natives for land to be first provided for; all the remaining revenue from every source (including Crown lands) to be under the control of the General Assembly, but all money votes to be brought forward by the Governor.

The Sovereign to have the power of vetoing all acts within two years; and the Governor to have the power of reserving acts for the approval of the Sovereign.

6. *The natives* to be under the laws of the Colony; but the Sovereign to have the power of appointing native districts which shall be exempt from these laws; the Sovereign only to have the power of purchasing land from natives.

4. GOVERNMENT AND LAND.

II. PROVINCIAL GOVERNMENT.

7. The Colony to be divided into six provinces : namely, Auckland, Wellington, New Plymouth, Nelson, Canterbury, and Otago.

8. Each province to be governed by a *Superintendent* elected by certain electors; the Governor to have a veto upon the election.

9. *And a Council*, composed of members elected for four years from the electoral districts.

10. *The Franchise* to be the same as for the General Assembly.

11. *The powers of Provincial Councils* to extend to making all laws for the government of the province, with the following exceptions:

Customs, high courts of law, currency, weights and measures, Post-office, bankruptcy, lighthouses, port dues, marriages, crown and native lands, criminal law, inheritance; and Europeans and natives to be treated alike.

12. The Governor to have the power of vetoing all acts within three months, and the general laws to supersede the provincial laws.

III. MUNICIPAL GOVERNMENT.

13. The Sovereign to have the power of establishing municipal corporations similar to those in England; the municipal laws to be subject to the approval of the provincial government.

REMARKS ON THE CONSTITUTION.

I do not pretend to give an opinion concerning the political question of the best form of government for this colony. But in the case of New Zealand, and all similar colonies, the military question of defence against the natives becomes a very important one indeed, in the whole question of the best form of government, and as I do not think this has been fully considered or provided for in the Constitution of 1852, I venture to make the following remarks upon it.

The military part of the question is, *whether, if the colonists of New Zealand have the entire management of their own affairs, they will be able to protect themselves against the natives.*

* It has been proposed that the settlers in that case, would, 1. Either form friendly alliances with the native tribes; or, 2, have a line of demarcation, or, 3, form a strong armed militia; and, 4, that there is little or no chance of future war.

1. † But the history of the colony shows that it was the very quarrels between the settlers and the natives that caused the Government to interfere originally; and the natives began to quarrel with the New Zealand Company before the Government arrived at Cook's Straits; ‡ and there never has been a colony yet formed among savages, by private or public enterprise, that there were not wars between the races, sooner or later.

2. And it is one of the most important features in the New Zealand natives, that their villages and cultivations are so intermixed with those of the settlers that it would be impossible to draw a line of separation between native and European in any part of the colony.

3. As to the question, whether by a militia alone they could preserve peace; § Captain Fitzroy has given his opinion, that in his time, at all events, "a strong

* Nelson Pet. 45. Fox, Six Cols. † Mr. G. Wakefield, Art of Colon.
‡ Col. Wakefield's Dispatch, 40. § Capt. Fitzroy's Pamphlet, 1846. Mr. Martin's Cols.

military force was necessary to overawe the natives;" and he was of a totally contrary opinion when he first went out to the colony: and that "the colony could not then afford to enrol one-fourth part of the militia authorised by law," and that after the destruction of *Kororarika* the settlers thought more of leaving the colony than of arming for its defence. And I think the circumstances of the Wairau Massacre, and * the proposition of the Wellington settlers to leave the colony, and the constant demand for protection, from all parts of the colony, show that, however well disposed and well qualified they may be to protect themselves when supported, without that support there is every appearance that New Zealand, instead of being in a more flourishing condition than it is, would have been almost entirely deserted.

4. GOVERNMENT AND LAND.

I believe that, as was expressed by the colonists at the time, it was necessary for the preservation of the colony that the British Government should interfere with a strong hand. They did interfere; and although they took a long time to terminate the quarrels with the natives, they did persevere, and at the cost of 200,000*l.* a year to the British nation, did establish such a flourishing condition of things in New Zealand, that the colony is now justly held up by Government officers and companies as one of the most eligible sites for British colonisation.

4. As to the question of future wars, there is certainly no prospect at present of war in any part of the colony; there is no existing cause for dispute, except the natural animosity of the savage to the spread of civilisation; but that has been the main cause of all wars with savages: and there are still in New Zealand 90,000 natives, allowed by everybody to be but little advanced in civilisation from their original state, or at least only advanced to that half civilised state which has always been more dangerous than the wholly wild savage; † and 20,000 Europeans pressing on them from different points; ‡ some causes of quarrel must arise, and may or may not be fanned into a flame by mismanagement, and into a conflagration by a little success of the natives.

I believe that if the colonists had the whole control over the colony, there would be a probability of continual wars, from the laws they would establish affecting the natives, and that before long it would eventuate, as has been stated concerning the Cape of Good Hope, in a war of extermination which would end in the desertion of New Zealand by the colonists.

I believe that whatever may be the best form of government for the European settlements, in order to preserve that peace, which has been so prosperous to the colony, it is necessary that the control of the natives, and of all questions connected with them and their lands, should be concentrated in a strong-handed government, under the authority of the British Government, supported by a regular military force, and a regular annual grant of money.

But I think that the number of regular troops and the grant of money might be considerably reduced from the present amount, if the colonists took a share in the defence against the natives *by assisting to pay a colonial corps: I believe that a colonial corps belonging to the colony and paid by them* (out of the Parliamentary grant, if necessary, but paid by the colony), *and supported by a small force of regulars, would be a much more effective force against the natives than regular troops alone;* and tend, by interesting the colonists in the defence of their own country, to preserve the peace more than the present two regiments of regular infantry. Such a corps would be only an extension of the present armed police force, in

* Local Papers of the time. † Bishop Selwyn; Fox, Six Cols.
‡ See Sir G. Grey's dispatch, 1849, July 8.

4. GOVERNMENT AND LAND.

which both natives and Europeans would serve. The organisation I would propose for such a force is given more in detail in the conclusion.

This is the point which I think has not been sufficiently provided for in the Constitution of 1852. When that Constitution was given, the colony should have been called upon to provide such a force as above described. There is now greater danger of conflict with the natives than there was under the old Constitution. For although the Government is not entirely in the hands of the colonists, yet the Governor is now almost single-handed between the naturally encroaching settlers, and the, as naturally, resisting savages: and the means at his disposal for preserving peace are no better than they were in 1846; two regiments of the regular army, paid out of the imperial treasury; while the settlers will not only pay no part of the expenses of a war, but will greatly benefit their colony by the profits of a large war expenditure paid entirely from England.

## LAND.

LAND.

The sale of land is under the control of the General Assembly, the whole of the *waste lands*, that is, those unoccupied either by English or by natives, being invested in that body for the benefit of the British nation, and not being the property of the colony alone. It is sold in the colony at from 1*l.* to about 30*l.* per acre, according as it is more or less rural or townland; and the proceeds are applied to assisting the migration of labourers, and making surveys. The New Zealand Company, and the associations connected with it, have sold land at from 1*l.* to 4*l.* per acre rural land; the purchase has been generally carried on in England, the purchaser receiving an order for so many acres and a passage out, at a low rate, for his money. At all the settlements almost the whole of the country in the neighbourhood of the towns has been sold in this manner; and as, from the disturbances, the proceeds of the land-sales have been all expended, there are at present very small funds for the assistance of emigration, and very little favourable land to tempt purchasers, from which funds could be raised.

But as the New Zealand Company is now defunct, most of the land purchases are conducted by the Government in the colony; the emigration of labourers is assisted by the Emigration Commissioners in England, who have the charge of expending the money raised by the land fund, in assisting poor emigrants out.

The Government also lease large tracts of land to settlers at a very cheap rate for grazing purposes. This stock farming is a very profitable business in New Zealand, and is occupying the attention of the settlers much more than agriculture, as the exports show.

As a general rule, emigrants of the better classes should spend as little money as possible, previous to arriving in the colony; it is during the first year or two that the settler most requires ready money. It is better that he should expend a little more money on his passage, and in examining the different settlements for himself, than run the risk of buying an unknown tract of land before he leaves England.

As to the working man, all he has to do is to get to the colony; whatever trade he is, and whatever part of the colony he lands in, he is sure of a livelihood.

The cost of a working man's passage to New Zealand is from 15*l.* to 20*l.*; but under the Emigration Commission the passage is much cheaper.

5. CLIMATE AND PRODUCTIONS.

## SECT. V.—CLIMATE AND PRODUCTIONS.

*The climate* is the grand characteristic which makes this colony so important to the British empire. Of all the Australasian countries, this has the climate nearest approaching to the British.* It is considerably more temperate, being within 34° and 48° S. latitude, but from the circumstance of the islands being long, narrow, and mountainous, and 1000 miles from any continent, it is perpetually refreshed, and kept in equilibrium as it were, by sea breezes; and is not nearly so hot and arid as the southern parts of the Australian continent, which are in the same latitude. It is well described by Mr. Weld† thus: "The climate of New Zealand, though one of the most variable within certain limits, is at the same time perhaps the most strictly temperate, both in summer and winter, of any in the world."

‡ There are constant strong winds blowing, generally speaking from the northward in summer, when they are strongest; and from the southward in winter, when they are rainy. There are about 200 days north-west winds, and 160 days south-east winds.§ There is a great deal of rain during the winter, averaging 31 inches in the year, but scarcely any frost or snow, except on the high mountains. Thus it will appear that the climate, though not very agreeable either to the sailor or the inhabitant, is very healthy, and very fertile for animal and vegetable; and will produce abundantly all the British grains and fruits, even to the grape, in the open air: and is particularly favourable to the constitution of Englishmen. Shocks of earthquakes are occasionally felt. Some that occurred in October, 1848, were the strongest that had been felt for many years by the natives; they shook down some brick houses in Wellington.

*The geological structure*|| is chiefly *primary;* the long narrow ranges of mountains are almost entirely composed of the *lower slate rocks,* intersected with veins of *basalt,* and with numerous *volcanoes* rising in high cones, of which there is only one (Tongariro, near Lake Taupo in the North Island) ever seen in action, and that only slightly. The rocks are therefore chiefly *basalt and scoria, slate, primary sandstone and limestone.* There is a great deal of *pumice-stone;* and there is good *sulphur* about the lakes Taupo and White Island (Bay of Plenty), in sufficient quantities to constitute an important article of export. *Copper ore* is worked near Auckland.¶ *Titanic iron sand* is brought down by several rivers; and along the west coast, from the Waikato River to Cape Farewell, the carboniferous strata appear in different parts. The *coal* crops out on the Waikato river, at Mokau on the coast, on the Wanganui river, and in Blind Bay, where there is also fossiliferous *limestone* and *sandstone;* and *coal* is also found on the Canterbury plains and Molyneux river; ** and chalk is found in the cliffs of the east coast about Cape Turnagain.

The flat plains between the mountains are composed of the detritus from the older rocks, as clay, sand, and boulders mixed with lignite, and lying in horizontal strata.

A little north of Otago, boulders of *Septaria* or Roman cement stone are found very plentiful in the cliffs.†† The *soil* throughout the whole country is generally a sandy clay with gravelly beds, being the diluvium from the mountains into the flats below; but owing to the climate it is very fertile, especially where the ancient

* Mr. Martin's Cols. † Weld, Pamphlet, 1851. ‡ Diffenbach.
§ Dr. Thompson, 58th Regt. Report; B. B. 1851. || Diffenbach and Mantell.
¶ See Exports. ** M. Martin's Cols. †† Mantell.

5. CLIMATE AND PRODUCTIONS.

forests remain. The Handbook of New Zealand estimates the available land for pasture or agriculture at two-thirds the whole area of the islands, which I think is a very high estimate.

*The indigenous vegetable productions* are, first and chief, the *Kauri pine*, one of the strongest and most durable pines in the world. It does not grow south of Lake Taupo. From thence to North Cape it is found everywhere in great abundance, and so large that spars from 50 to 100 feet long, and 3 to 6 feet diameter, are procured without great difficulty, and form a chief article of export. There are other good building pines all over the islands, of great size; and trees something similar to the English oak, beech, and elm; but pine is the grand staple. The second important production is the *Phormium tenax* or *flax*, which covers square miles of the country; it grows like English *flags* in great clumps, having long narrow leaves springing from the ground, and about 3 inches broad and 5 feet long. The fibre is obtained from these leaves, and has been always used by the natives, and is worked by the colonists into rope, wool bags, &c., but nobody has yet succeeded in cleansing it sufficiently (by a cheap process) to clear off a gummy substance in it, which causes it to go in the bend after a few months' wear. It is exported in a half-dressed state from all parts of New Zealand to the Australian colonies at about 12*l.* per ton.

The other vegetable productions are chiefly those of a semi-tropical climate, as ferns, palms, &c. Of the grasses, the *Toi toi* will be found very useful in campaigning, being the chief substance used at out-stations for thatching the roofs of huts; and the *Raupo*, a rush which is commonly used for thatching the walls.

The trees are described under the head of building materials.

The principal productions of the *north* are *copper ore* and *Kauri pine timber.** The former is found near Auckland, on the coast of Houraki Gulf, and is sent to England in the raw state. The latter is shipped to the Australian colonies and England from different ports in the north.

The principal productions of the *south* are *wool* and *pine timber.*† The greater extent of grassy plains in the south have made it a greater stock country than the north. The wool is exported direct to England, and is considered very good, though not yet equal to the Australian; there is grazing country in New Zealand for several millions of sheep.

At present the colony does not wholly supply itself with *wheat;* but from the fertility of the climate, it will no doubt become the chief granary of Australasia. The natives supply a considerable quantity of wheat and pigs to the different settlements. The pigs, left by Cook and other navigators, having spread over the whole country, have become wild, and are obtained in sufficient quantity to form an export of salt pork. These supplies of wild pork and wheat are of very great assistance to the outsettlers, in all parts of the colony where there are natives.

*Price of Provisions at Wellington*, 1848.‡

| | | £. | s. | d. | | | £. | s. | d. |
|---|---|---|---|---|---|---|---|---|---|
| Bread | per lb. | 0 | 0 | 2 | Sugar | per lb. | 0 | 0 | 3 |
| Fresh butter | ,, | 0 | 1 | 3 | Tea | ,, | 0 | 2 | 0 |
| Coffee | ,, | 0 | 0 | 6 | Tobacco | ,, | 0 | 1 | 9 |
| Flour | per ton | 14 | 0 | 0 | Artificers' wages | per day | 0 | 6 | 0 |
| Beef and mutton | per lb. | 0 | 0 | 6 | Labourers' do. | ,, | 0 | 3 | 0 |
| Pork | ,, | 0 | 0 | 5 | | | | | |

* Col. returns. † Weld. ‡ Statistics, New Munster, 1850.

There would be no difficulty in supplying troops with provisions, either of beef, mutton, or pork, and bread, in any part of New Zealand, provided some notice was given beforehand.

5. CLIMATE AND PRODUCTIONS.

BUILDING MATERIALS.

*Timber.**

1. *Kauri* pine (*Dammara Australis*). This is a fine cream-coloured, close-grained pine, without knots, and clean; and is useful for ships' spars and decks, and all purposes of house-building. Experiments at the Dockyard, Chatham, in 1834,† give the relative transverse strength of Kauri at 730, oak being 1000; other experiments at the same place make it equal to oak. It is the most lasting pine in water, except Totara, and grows all north of Lake Taupo; averages 5 feet diameter, and 50 feet trunk to branches. Clay soil. This timber is probably the only one in New Zealand equal to Baltic pine.

2. *Kahikatea*, white pine (*Dacrydium excelsum*), grows chiefly in the south. This is a fine white clean wood, very useful for indoor work, but not a lasting timber; very plentiful; averages 4 feet diameter, and 40 feet to branches. Rich soil.

3. *Rimu*, red pine (*Dacrydium cupressum*), grows chiefly in the south; a strong red-grained pine; very useful for all carpenter's work and furniture. Average same as white pine; grows on the hills. Strength, 700.

4. *Totara* pine (*Podocarpus totara*), grows in the south; a fine clean wood of a red colour; useful for waterwork; is the most lasting wood; used always for canoes; has little transverse strength. Averages larger than white pine. Rich soil. Split easily.

5. *Puriri* (*vitex littoralis*) grows in the north; very much the character of English oak. Not very large nor very plentiful.

6. *Mai* or *Matai* pine (*Dacrydium Matai*), grows chiefly in the south; a fine clean wood of a yellow colour, very good for furniture and all joiner's work. Averages smaller than white pine.

7. *Mairi* (*Podocarpus macronata*) grows chiefly in the south; a dark close-grained hard wood; lasting; useful for engineering purposes; strong and heavy.

8. *Rata* (*Metrosideros robusta*) grows in the south; a tough twisted grain, red colour; useful for ship's knees, &c.; hard and difficult to cut. Averages a large tree, but with a trunk composed of several small trunks united.

9. *Pohutukawa* (*Metrosideros excorticata*) grows in the north; similar to the *rata*.

10. *Titoke*, a small tree, light streaked grain; useful for all purposes to which ash is applied.

11. *Manuka* or *Kahikatoa*, Tea tree (*Leptospermum scoparium*), a small tree, very common, like the Scotch fir in appearance, dark hard wood; used for paddles, spears, axe handles, &c. Very good firewood.

The timber is sawn chiefly by hand, but there is no reason why steam and water saw-mills should not be generally used; it seldom has time to season, and therefore generally shrinks. It is expensive, being about 10*s*. per 100 feet superficial of 1 inch thick; the expense is caused by the difficulty of transport. Blue gum timber from Van Diemen's Land can be procured as cheap.

Houses are generally built throughout the colony of a frame-work of timber, weatherboarded outside, and roofed with shingles. In consequence of the earthquake of 1848, the soldiers' barracks, then about to be built in Wellington, were made in this manner; of the best timber, and on a brick foundation, and brick-nogged and lined with boards.

* Bishop Selwyn's Journal, 1846. Handbook, N. Z.

† Prof. Pap. R. E. vol. 5.

5. CLIMATE AND PRODUCTIONS.

BUILDING MATERIALS.

*Bricks.*—There is no difficulty in obtaining bricks in any part of New Zealand, for there is clay almost everywhere fit for their manufacture. There are brick kilns in all the towns. Their price in Wellington, in 1848, was 30*s.* per 1000.

*Stone.*—There is difficulty in procuring good building stone in all the settlements. In the north, *scoria* is used, dressed from the rough heaps round the extinct volcanoes. It is very hard and impracticable. There is nothing at Wellington but a rotten schist only fit for rubblework; but there is granite, and sandstone, and limestone to be obtained, as at Nelson for instance, though the expense would be very great at present.

*Lime.*—Is generally made from shells in New Zealand, but sometimes from limestone from Nelson: this stone can be obtained from other places on the west coast, as before stated (p. 27). Shells for lime can be obtained everywhere on the coast, and make very fair lime. Lime is about 2*s.* 6*d.* a bushel. Roman cement stone, as before stated, is to be got near Otago; it would be very valuable in New Zealand to protect the exteriors of the wooden houses against weather and fire, but the expense prevents its being used at present.

*Ironwork, glass, and all fitments and castings* can be obtained from Sydney or Hobart Town.

The chief difficulty that has been felt in New Zealand in building has been the want of good artificers; that difficulty is not likely to be diminished for some years to come, owing to the slow increase of the population; therefore in case of any works being undertaken by the Royal Engineer department in New Zealand, or of any military operation, it will be absolutely necessary to send out a force of Sappers; and as these men would have to execute every branch of construction, from felling timber and making bricks, to the last finishing touch, it would be necessary to supply them with a complete equipment of tools for all these purposes, and also with carriages for transport. The want of such a force, so equipped, was a very serious impediment, and a cause of great extra expense during the whole of the military operations in 1845-6-7. Large working parties of the line and natives have been employed on all the ordnance works, both permanent and temporary; and also upon the colonial roads; and tools and stores had to be purchased for them on the spot at a great expense, and the men had to be instructed in their duties.

The natives make tolerably good labourers after two or three months' practice, and have executed some good mason's work under the Royal Engineer department at Auckland. I believe they could be taught all kinds of trades. They would not require the same wages as civilians, but they would not do the same amount of work; so that their labour would be as expensive as civilian labour. The armed police force I have mentioned as necessary for the defence, might no doubt be employed upon the public works of the colony, when not otherwise required. This force would include both Europeans and natives.

WATER.

There is no want of water in almost every part of New Zealand. It can be generally obtained from streams; but in all the towns there are wells, which, generally speaking, give a good supply. Owing to the volcanic nature of the strata, the results of boring for water are very irregular; on the low coasts, among the sandhills, it is difficult sometimes to get water within a few miles.

FUEL.

The principal fuel as yet used in New Zealand is *wood*. This is brought both by land and water from the forests in the neighbourhood of the towns, and is sold at about 16*s.* the *cord* of 144 cubic feet. All kinds of timber are used. It is already becoming so expensive that in many private houses coal from Sydney, at 30*s.* a ton, is used. The coal in New Zealand has not yet been worked sufficiently to be brought into use as a fuel. 5. CLIMATE, &c. — FUEL.

## SECT. VI.—COMMUNICATIONS AND HARBOURS.

6. COMMUNICATIONS AND HARBOURS. — TRANSPORT.

*Transport* is the grand difficulty that has been felt in the movement of regular troops in New Zealand; in the neighbourhood of all the settlements there are now good carriage roads, extending for a few miles, as has been described; but off the roads even in the settlements, and all beyond that, the whole country is either impracticable mountain forest or plains intersected with impassable swamps. To the outposts in the neighbourhood of the towns, all stores, baggage, and materials are transported by hired carts, of which there are plenty, drawn by horses. To the distant outstations, being all on the coast, everything is transported by small coasters suited to enter shallow rivers. There are plenty of these coasters, but in a climate like New Zealand there is no dependence to be placed on such transport.

* The only paths throughout the country are the natives', which generally follow the most difficult line for the sake of security against enemies, and the outsettlers use them, and not unfrequently lose themselves; † but they are passable, for Europeans frequently go through the whole country; and horses have been from Auckland to Wellington, and the outsettlers travel many miles on horseback by following paths. There is a monthly mail between these two places, carried by the armed police, viâ New Plymouth, along the coast the whole way, and it takes twenty days; but it was so uncertain that public documents were always sent by sea; and as there was no regular communication by sea, it sometimes took several months to get answers at Wellington from head-quarters at Auckland, which are only 500 miles distant.

The difficulty of transporting artillery and stores for even 20 miles into the interior will be seen in the accounts of the campaigns to have been the great impediment. Carriages will not be of use beyond the settlements for some years to come; all transport on land must be effected on horses (as the country is too difficult for pack-bullocks), or on men's backs; as it is done now by the settlers in both ways. The natives are great adepts in carrying loads for great distances; they will carry from 40 to 50 lb. 15 miles a day. The passage of the numerous small deep rivers is another great difficulty; the settlers always make for a native pah and cross in canoes, swimming their horses; but it might be effected in the case of military stores by portable indian rubber boats. The Mackintosh cloak-boat would be a most useful thing to a single traveller in New Zealand.

Small carts, both hand-carts and harness-carts, and also small boats, are very necessary things at all the stations for the transport of stores and materials in the neighbourhood of the stations.

See the "Corps Papers, Royal Engineers," part 3, 1849-50, for statement of distances by sea, and further report on communication.

I have extracted the following itinerary from the Bishop's Almanac (published in New Zealand), because it is generally useful and can be depended on. It is one of the many works of practical benefit to the colony, executed by that talented and zealous clergyman.

* Bishop's Journal, 1846. † Various people lost, 1847-8-9.

6. Communications and Harbours. — Transport.

## NEW ZEALAND ITINERARY.

COMPILED BY DR. SELWYN, BISHOP OF NEW ZEALAND, FROM PERSONAL OBSERVATION, AND PUBLISHED IN THE ST. JOHN'S COLLEGE ALMANAC.

### I. *Auckland to Wellington, Coast Road.*

| *Auckland* to | | Miles. | Description of journey. |
|---|---|---|---|
| Onehunga | | 6 | Open cart-road |
| Cross Manukau to Orua | | 10 | Dangerous |
| Waikato River (boat) | | 30 | Good beach |
| Whangaroa River (boat) | | 35 | Open and hilly |
| Aotea Harbour (boat) | | 18 | Woody, open |
| Kawhia (boat) | | 5 | Open |
| Tapirimoko | | 25 | Wood, beach, cliff |
| Mokau | | 25 | Good beach at low water |
| Waitera (boat) | | 35 | Cliffs, beach at low water |
| New Plymouth | 199 | 10 | Open cart-road |
| Mokotuna | | 20 | Beach, stones, grass |
| Otumatua | | 30 | Open, grass, sand |
| Waimate | | 18 | Beach at low water, stones |
| Patea River (boat) | | 26 | Beach, stones, sandhills |
| Waitotara | | 16 | Tide beach, sandhills |
| Whanganui River, M. S. (boat) | | 18 | Do. good beach |
| Whangaihu River (boat) | | 9 | Sand, beach |
| Turakina River (ford) | | 3 | Do. do. |
| Rangitiki River (ford) | | 17 | Do. do. |
| Manawatu River (ford) | | 13 | Do. do. |
| Otaki River, M. S. (ford) | | 20 | Do. do. |
| Waikanae, M. S. | | 10 | Do. do. |
| Porirua | | 24 | Sand, wood |
| *Wellington* | 238 | 14 | Wood |
| | | 437 | |

### II. *Auckland to Wellington, Inland Route, by Taupo.*

| *Auckland* to | Miles. | Description of journey. |
|---|---|---|
| Kaweranga (Mission Station) | 40 | By sea |
| Land at Te Rua Kowhawhe | 50 | River Thames (Waiho) |
| Matamata | 21 | Plain, swamp |
| Te Toa, Patetere | 26 | Plain, rivers. |
| Rotorua Lake | 27 | 20 m. wood, 7 m. open |
| Cross Lake to Te Ngae, M. S. | 6 | Boat |
| Tarawera Lake | 10 | Hill, open, lake |
| Rotomahana Lake and hot springs | 10 | 8 m. lake, 2 m. plain |
| N. end of Taupo Lake | 34 | Hills, plain, deep streams |
| S. end of Taupo Lake. Te Rapa | 25 | Lake, by land 35 m. |
| Makokomiko on Whanganui River | 42 | Open, woody, deep ford |
| Mouth of Whanganui, M. S. | 150 | River, rapids |
| *Wellington* | 110 | See No. I. |
| | 551 | |

6. COMMUNICATIONS AND HARBOURS.

III. *Auckland to Wellington, by East Coast.*

| *Auckland* to | Miles. | Description of journey. |
|---|---|---|
| Kaweranga | 40 | By sea |
| Opita. Sacred Creek | 30 | River Thames (Waiho) |
| Katikati | 25 | Open |
| Te Papa. Tauranga, M. S. | 20 | Boat, along Tauranga Bay |
| Maketu | 15 | 1 m. boat, 1 m. plain, 13 m. beach |
| Otamarora | 19 | Deep rivers, beach |
| Wakatane | 14 | Hills, beach, deep rivers |
| *Opotiki, Mission Station | 20 | Beach |
| Turanga. Poverty Bay, M. S. | 90 | Hills, beach, no villages |
| Nuhaka | 38 | Hills, wood |
| Wairoa River, M. S. | 20 | Beach |
| Waikare River | 31 | Beach, cliffs |
| Arapaoanui | 15 | Steep hills |
| Ahuriri, M. S. | 24 | Beach, inland water |
| Patangata | 21 | Plain, deep river |
| Rotoatara Lake | 10 | Open downs |
| Rua Taniwha Plain | 22 | Open, grass plain |
| Manawatu River | 22 | Long wood, plains |
| Te Rewarewa | 70 | Course of Manawatu River |
| Mouth of Manawatu | 9 | Sandhills |
| *Wellington* | 68 | See No. I. |
| | 623 | |

IV. *Auckland to Wellington, by Waikato and Waipa.*

| *Auckland* to | Miles. | Description of journey. |
|---|---|---|
| Mangatawiri Creek on Waikato | 45 | Open, wood |
| Pepepe, M. S. | 35 | Course of Waikato, rapid |
| Puehunui | 37 | Course of Waipa, still |
| Otawhao, M. S. | 10 | Open, fern |
| Rangitoto | 25 | |
| Tutakamoana | 28 | Open hill, plain |
| Waihoura on Taupo Lake | 8 | Open hills |
| Pukawa | 12 | Lake |
| Matahanea on Whanganui River | 26 | 15 m. open, 11 m. wood |
| Mouth of Whanganui River | 150 | Course of Whanganui, rapid |
| *Wellington* | 110 | See No. I. |
| | 486 | |

* *Opotiki to Turanga, Coast Road.*

| *Opotiki* to | | | |
|---|---|---|---|
| Tunupahore | 16 | Rangitukia, M. S. | 20 |
| Te Kaha | 18 | Waipiro | 20 |
| Whangaparaoa | 21 | Uawa, M. S. | 21 |
| Te Kawakawa, M.S. | 33 | Pakarae | 16 |
| | | *Turanga* | 22 |

Total, 187 miles.

6. COMMUNICATIONS AND HARBOURS.

### V. *Auckland to Wellington, by Wairarapa.*

| *Auckland* to | Miles. | Description of journey. |
| --- | --- | --- |
| St. John's College | 6 | |
| Papakura, native village | 15 | Plain, cart-road |
| Tuimata | 10 | Fern hills |
| Tuakau | 10 | Fern hill and woods |
| Tukupoto, M. S. | 45 | Up Waikato River |
| Puehunui | 37 | Course of Waipa River |
| Arowhena | 25 | Open |
| Tuaropaki | 28 | Open hills and plain |
| Tutakamoana | 12 | Do. do. |
| Pakaunui | 18 | Do. do. |
| Pukawa, on Taupo Lake | 10 | Do. do. |
| Tauranga River on do. | 12 | Lake |
| Tangoio: Hawke's Bay? | 60 | Hills, woods |
| Ahuriri, M. S. | 17 | Beach, harbour, beach |
| Waimarama | 19 | Sand, ridge, sand |
| Manawarakau | 13 | Do. do. |
| Porangahau | 30 | Stones, sand, stones |
| Pakuku | 18 | Fern hills, swamp, grass |
| Mataikona | 20 | Stone, fern, sand |
| Rangiwhakaoma | 15 | Sand |
| Leave Beach | | |
| Whareama | 6 | Steep bare hills and valleys |
| Kaikokirikiri | 30 | Woods, hills, grass plain |
| Hurinui o rangi | 9 | Short woods and plain |
| Ahieruhe | 4 | Grass plain |
| Huangarua River | 8 | Do. |
| Rimutaka range? | 6 | Wood, hilly |
| Mungaroa | 8½ | Cart-road |
| Second Valley | 8 | Do. |
| Hutt Bridge | 8 | Do. |
| *Wellington* | 9 | Do. |
| | 541 | |

### VI. *Auckland to Wellington, by Taupo and Waikare Lakes.*

| *Auckland* to | Miles. | Description of journey. |
| --- | --- | --- |
| Rotorua Lake | 164 | See No. II. |
| Ohinemutu | 6 | Lake |
| Rotokakahi Lake | 8 | Grass hills and wood |
| Ohaki, hot springs | 25 | Dry hills, plain |
| Te Takapau | 5 | Dry plain. Waikato. |
| Taupo Lake, N. end | 11 | Do. |
| Waitahanui River | 5 | Shore of Lake |
| Rangitaiki River | 20 | Dry bare plain |
| Te Ngaere | 11 | Do. do. |
| Tututarata | 15 | Do. hills. |
| Ahikereru, M. S. | 12 | Hills |

VI. *Auckland to Wellington, by Taupo and Waikare Lakes.*
(Continued.)

6. COMMUNICATIONS AND HARBOURS.

| *Auckland* to | Miles. | Description of journey. |
|---|---|---|
| *Oputao | 15 | Wood, steep hills |
| Waikare Moana | 16 | Steep wooded hills |
| Wairoa River, M. S. at mouth ? | 60 | Lake, river |
| *Wellington* | 292 | See No. III. |
| | 665 | |

VII. *Auckland to Kaitaia, by East Coast.*

| *Auckland* to | Miles. | Description of journey. |
|---|---|---|
| Mahurangi | | |
| Whangarei | | |
| Ngunguru | 14 | Open hills, beaches |
| Whangaruru Harbour (Owae) | 35 | |
| Waikare River, Bay of Islands | 22 | 16 m. water, 6 m. land |
| †Paihia, Mission Station | 10 | Course of Waikare River |
| ‡The Kerikeri, M. S. | 16 | Cross the Bay of Islands |
| Whangaroa, M. S. | 25 | Open, hills |
| Mangonui | 16 | 4 m. water, 12 m. land |
| Taipa River, Oruru | 2 | Open |
| *Kaitaia* | 17 | Open |

VIII. *Auckland to Kaitaia, by Kaipara and Whangaroa.*

| *Auckland* to | Miles. | Description of journey. |
|---|---|---|
| Head of Waitemata River | 14 | Tideway |
| Head of Kaipara River | 15 | Open, hills |
| Mouth of Kaipara River | 40 | Tideway of Kaipara River |
| Te Otahi, Wesl. M. S. | 80 | Tideway of Wairoa River |
| §Mangungu, Wesl. M. S. ? | 70 | River, wood |
| Mangamuka | 15 | Tideway of Mangamuka River. |
| *Kaitaia* | 25 | 14 m. wooded ridge, 11 m. plain. |
| | 259 | |

* *Ruatahuna and Waiti villages.*

| | Miles. | Descrip. of journey. |
|---|---|---|
| Oputao to Whakapapa | 10 | Steep wooded hills |
| Whakapapa to Toreatai | 14 | Do. do. |
| Toreatai to Tauaki | 5 | Do. do. |
| Tuaki to Maruteane | 12 | Do. do. |
| Maruteane to Waikare River | 12 | Do. do. |
| Waikare village to Tunganui | 8 | Do. do. |
| Tunganui to Ruatoki | 13 | Bed of river |
| Ruatoki to Wakatane | 18 | Plain. |

† Paihia to the Waimate, 15 m. ‡ The Kerikeri to the Waimate, 10 m.

§ Mangungu to the Waimate, 20 m.

6. COMMUNICATIONS AND HARBOURS.

IX. *Auckland to Stewart's Island.*

| *Auckland* to | Miles. | Description of journey. |
|---|---|---|
| *Wellington . . . . . . | 437 | See Route I. |
| The Wairau . . . . . . | 30 | By sea |
| Kaikoura . . . . . . . | 50 | Beach, stones |
| Matanau Island, Whaling Station . . | 50 | |
| Port Cooper . . . . . . | 40 | Beach |
| Port Levy . . . . . . | 4 | Steep hills |
| Pigeon Bay. . . . . . . | 6 | Do. |
| Akaroa . . . . . . . . | 12 | Do. harbour. |
| Pireka, Whaling Station . . . | 8 | Do. |
| Ikurangi, Whaling Station . . . | 8 | Do. |
| Taumutu . . . . . . . | 20 | Shingle bed |
| Te Wai a Te Ruati . . . . | 61 | Grass plain, shingle beaches |
| Waitangi River (dangerous) . . | 54 | Do. do. |
| Moerangi, Whaling Station . . . | 39 | Do. sand |
| Waikouaiti, Wesleyan M. S. . . | 23 | Beach, hills |
| Otakou . . . . . . . . | 17 | Steep hills |
| Taiari, Whaling Station . . . | 30 | |
| Molineux Harbour, Matau River . . | 18 | |
| Tautuku, Whaling Station . . . | 18 | |
| Awarua, The Bluff, Whaling Station . | 57 | Flat, beach |
| New River . . . . . . . | 6 | Do. |
| Aparima, Jacob's River, Whaling Sta. | 12 | Beach |
| Whakaputaputa . . . . . . | 6 | Do. |
| | 1006 | |

X. *Auckland to Stewart's Island.*

| *Auckland* to | Miles. | Description of journey. |
|---|---|---|
| Awarua, the Bluff . . . . . | 982 | |
| Ruapuke . . . . . . . | 12 | Foveaux Straits |
| Stewart's Is., the Neck, Paterson's R. | 8 | By sea |
| Half Moon Bay . . . . . . | 2 | |
| Horse Shoe Bay . . . . . | 2 | |
| Port William . . . . . . | 2 | |
| Murray River . . . . . . | 4 | |
| Saddle Point . . . . . . | 6 | |
| Raggedy Point . . . . . . | 11 | |
| Codfish. Passage Island . . . . | 3 | |
| | 1032 | |

The land distances in the above Itinerary were chiefly measured by Payne's Pedometer; but, as that instrument is liable to errors on hilly and broken ground, the measurements cannot be entirely depended upon.

* Wellington to Nelson, 150 m.

6. COMMUNICATIONS AND HARBOURS.

### List of the Principal Harbours of New Zealand.*

HARBOURS.

#### North Island.

1. *Monganui Bay,* in Doubtless Bay: a small harbour of easy access, and safe for medium-sized vessels; a resort of whale ships.

2. *Wangaroa Harbour:* a spacious, deep, and well-sheltered harbour, but very narrow and bold entrance.

3. *Bay of Islands:* a small gulf, sheltered by several islands, of easy access in all weathers, safe anchorage at the head.

4. *Wangaruru, Tutukaka, Wangari:* small harbours, accessible and safe for medium vessels; H.M.S. "Calliope" once took refuge in Wangari.

5. *Houraki Gulf:* into this large gulf vessels can obtain easy access: it has numerous anchorages, of which the principal are—

*Auckland:* an estuary, three quarters of a mile wide, clear deep channel, accessible for all vessels; strong tide and strong winds blowing up and down the channel.

*Barrier Island* (Port Abercrombie): accessible and safe for all vessels.

*Kawau Island and Bay* (Copper Mine): a good harbour for all vessels.

*Coromandel Harbour:* accessible and safe for all vessels.

*The Thames River:* is only accessible for boats.

There are several other anchorages in Houraki Gulf available in particular winds.

6. *Hokianga River:* like all the rivers and harbours on the west coast, it is barred or fronted with sand-banks, on which the sea rolls with unbroken fury in westerly gales, rendering them uncertain of access except in moderate weather. This has always been a great trading place in Kauri spars; vessels of 500 tons go several miles up the river: 19 feet the deepest draught of shipping that has been in.†

7. *Kaipara,* see No. 6: a large estuary formed by several small rivers, fronted with numerous sand-banks, and reported the most dangerous harbour to enter in New Zealand; a great trading-place for Kauri spars; vessels of 400 and 500 tons can enter.

8. *Manukau Harbour* (opposite Auckland), see No. 6: deep, tortuous channels through sand-banks, difficult of access from strong tides and heavy swell; safe anchorage inside; a good point of communication for steamers from Australia. From Manukau canal communication might be made to Auckland Harbour and Waikato River, the isthmus in both cases being only one mile across, low land.

9. *Mercury Bay:* a small harbour accessible and safe in moderate weather for all vessels. *From this point to Port Nicholson there are no safe harbours for vessels of more than* 200 *tons,* but numerous anchorages in off-shore winds.

The principal small craft havens are as follows:—

10. *Tauranga Harbour:* a small harbour, narrow entrance, for coasters, accessible for steamers.‡

11. *Hicks' Bay* (East Cape): accessible and safe in southerly weather for all vessels. H.M.S. "Driver" took refuge here in a N.E. gale.§

12. *Tokomaru, Tologa, Bay:* small, accessible, and safe in off-shore winds.

* Corrected by W. Evans, Esq., R.N., late master and assistant-surveyor of H M.S. "Acheron."
† Col. Wakefield. ‡ Capt. Henderson, R.A. § Capt. Henderson, R.A.

6. COMMUNICATIONS AND HARBOURS.

HARBOURS.

13. *Poverty Bay* has a sheltered haven with a bar entrance, accessible and safe for vessels in off-shore winds.

14. *Ahuriri* has a small bar harbour, accessible and safe for coasters. *No haven between this and Port Nicholson.*

15. *Waikato River*, see No. 6: coasters only can cross the bar at low water; difficult of access from sand-banks, navigable for coasters for 50 miles. *The Waipa River* is also navigable for coasters for a short distance.

16. *Wangaroa Harbour*, see No. 6: for coasters only.

17. *Kawia Harbour*, see No. 6: 2 fathoms on bar at low water, 12 feet rise; accessible, but difficult for all vessels; 1¼ mile wide.

18. *Mokau River*, see No. 6: for coasters only.

19. *New Plymouth* (Taranaki): a roadstead, very unsafe in northerly weather. *Waitera River*, 10 miles north, accessible for coasters.

20. *Wanganui River:* a bar river, 6 feet at low water, navigable 4 miles; for coasters only. *The rivers on this side Cook's Straits are inaccessible in heavy weather.*

21. *Manewatu River:* a bar river, 7 feet at low water, navigable 20 miles; for coasters only; see No. 20.

22. *Kaputi Island* (Entry Island): small but secure anchorage on the east side for all vessels; sheltered from both N.W. and S.E. winds, which are the prevalent winds in Cook's Straits. A common rendezvous for vessels going through the straits.

23. *Porirua:* accessible and safe for coasters in all weathers.

*Mana Island* at its entrance affords shelter close under its lee in N.W. winds.

24. *Wellington* (Port Nicholson): accessible and safe for all vessels; difficult of ingress and egress in strong winds, owing to the narrow entrance, three quarters of a mile, lying parallel to the Straits. A lighthouse is very much required to mark the entrance, which is not easily distinguished in thick weather. There are constant strong winds in Cook's Straits from N.W. or S.E.

### MIDDLE AND SOUTH ISLANDS.

25. *Massacre Bay:* in this bay there is secure anchorage for all vessels near Tata (where coal is found).

26. *Blind Bay, Astrolabe,* and *Fisherman's Roads:* safe and accessible for vessels in all weathers, but small.

*Nelson Haven:* a very small harbour, formed by a natural breakwater, with a very narrow entrance, strong tide, rise 12 feet; difficult of access, but safe for vessels of 1000 tons.

There is seldom bad weather at the head of Blind Bay.

*Croixille's Harbour:* easily accessible, and safe for all vessels in all weathers; the best port in N.W. gales in Blind Bay.

27. *Port Hardy:* accessible and safe for all vessels.

28. *Admiralty Bay:* there are numerous good anchorages about this bay, accessible in all weathers.

29. *Queen Charlotte's Sound:* accessible and safe in all weathers; deep except in the coves, where good anchorage is to be found. The tides are very rapid off the entrance.

30. *Port Underwood:* easily accessible and safe in all weathers; a frequent harbour of refuge for vessels to enter Port Nicholson, or to go through the Straits.

*From Cape Campbell to Banks' Peninsula no havens.*

Temporary anchorage under Kaikora Peninsula in off-shore winds. 6. COMMUNICATIONS AND HARBOURS. — HARBOURS.

31. *Banks' Peninsula, Port Cooper* or *Victoria* (Canterbury): accessible and safe in all weathers, slightly open to the eastward; northerly winds bring a heavy swell in.

*Akaroa:* a fine port, open to the south; no hidden danger, moderate depth all over, sometimes dangerous of access owing to violent flaws of wind and heavy swell at entrance.

There are other fair harbours in Banks' Peninsula.

32. *No safe anchorage between Banks' Peninsula and Otago except Moerangi and Waikouaiti,* anchorage in off-shore winds only.

33. *Otago:* a bar harbour, inaccessible in easterly gales, 17 feet at low water; vessels of 800 tons have entered; anchorage confined and tides rapid.

34. *Molyneux River:* anchorage with off-shore winds, river dangerous to enter at all times; for coasters only.

35. *Bluff Harbour:* formerly frequented by whalers; confined anchorage; difficult of ingress and egress from rapid tides at entrance (7 knots).

*From Bluff to Preservation Sound no harbours.*

36. *Stewart's* or *South Island, Port William,* and *Paterson's Inlet:* both safe for all vessels in all weathers; the nearest harbour to the Bluff country. There are other good harbours in Stewart's Island.

37. *Chalky Bay, Dusky Bay, Milford Haven:* all very deep harbours or estuaries; tempestuous weather; very mountainous, impracticable country; used by whale ships.

*No anchorage between Milford Haven and Massacre Bay, except Jackson's Bay,* and that not safe in northerly winds.

### General Remarks.

The above are the principal harbours and rivers in New Zealand; generally speaking, the good harbours are on the east coast. Those on the west coast are generally bar harbours. There are several other small rivers into which coasters can enter at high water.

The flood-tide appears (speaking in a general manner) to strike the south end of New Zealand, and run northwards up both coasts; but it is very irregular. In Foveaux Straits it runs from N.E. to S.W., in Cook's Straits from S. to N. It is high water at full and change; at 12 at Stewart's Island; at 4 at Port Cooper; at 4½ in Port Nicholson, but 9 in Cook's Straits; at 7 in Houraki Gulf.

An average rise of tide is 6 feet on the east coast, and 10 feet on the west coast. About Blind Bay and New Plymouth it is 12 feet.

Brief sailing directions for the principal harbours are generally to be found in the almanacs published in the colony.

## Sect. VII.—Defences.

These in New Zealand may be divided into *External* and *Internal.* 7. DEFENCES.

Of *External* defences against a foreign enemy, there are none worth mentioning. At Auckland there are some 32 pounders on Point Britomart, a military post in a very good position, being a cliff-point, commanding the harbour, and about 60 feet above the water; but these guns are not mounted, and there is no protection for them or for any of the troops and stores against a man of war. There are no heavy guns, or batteries, or forts, at any of the other settlements;

7.
DEFENCES.

neither are there sufficient positions reserved for these objects at any of the settlements. There has been some difficulty experienced in obtaining sites for ordinary barracks for the troops; the proper military positions have not been selected, and have been sold to private persons. There are also one frigate, one sloop, one steam-sloop, all fully armed and manned, always upon the station; and the colonial brig of 200 tons, but carrying no guns. The station includes Australia.

The *Internal* defences against the natives consist at present (1851) of two regiments of the line, mustering about 1000 men together, and 25 Royal Artillery, with some field guns, and 500 Pensioners, and about 50 armed Police, partly Europeans and partly natives.

*In Auckland* there are about 500 men; there are some stone buildings, but most of the men are in temporary wooden buildings, on Point Britomart, and on the Albert Hill in the rear of it. This latter is a good position for defending the land front of the town; and it is enclosed with a flanked and loop-holed stone wall. There is only a slight enclosure to Point Britomart. There are good magazines and storehouses.

*The Pensioners** arrived from England in 1847-8, and have been located in six villages to the south of Auckland, at 6 to 13 miles distant. They are armed, and are occasionally called out under their officers, but their villages are not defensible. There are about 25 *armed Police* in Auckland, natives and Europeans. They are employed on the ordinary duty of police, and in carrying the mails, and served during part of the military operations. They are on foot, and are armed with a carbine and bayonet.

At *the Bay of Islands* there are about 100 men. They live in a hired building near Kororarika, not defensible in itself or of any use to the town.

At *Wellington* there are 400 men. They live in wooden barracks, on Mount Cook, a tolerably good position, commanding that part of the town, but not at present defensible in itself. There are no quarters for officers and no storehouses, the Ordnance and Commissariat stores being in hired buildings. There is a good magazine; there are some detachments at Porirua, and in the Hutt Valley, left there since the war in 1847, but they are only temporary, and not now in defensible positions.

At *Wanganui*, there are 200 men, in a stockade, with blockhouses of wood, on a hill commanding the town, and containing magazines and storehouses.

The Artillery are divided between Auckland and Wanganui.

There are 20 police in Wellington. The remainder are at New Plymouth, and other settlements. But there are no troops in any other settlement, and *no militia in any part of New Zealand*, although there are some arms for them in possession of the Colonial Government.

During the war in 1846-47-48, the strength of the two regiments was 2000, and there were about 300 to 400 militia called out.

There was a great want of a Field Engineer Equipment, as well as of a company of Sappers, during the military operations, of means of crossing the numerous rivers, of cutting through the forest, of stockading and intrenching, and of portable powder magazines, all of which would still be wanted if military operations should recommence.

* Martin's Cols.

8. GEOGRAPHICAL ADVANTAGES.

## SECT. VIII.—GEOGRAPHICAL ADVANTAGES.

New Zealand, though situated in a favourable position for sea communication with China and Australia, America and England, is not in the direct line of intercourse between any of these places, and therefore must depend upon her own resources for a commerce. Vessels will not call at New Zealand merely *en route,* they must have some object to induce them to call there. The present intercourse consists as follows:

| | | |
|---|---|---|
| With England | To New Zealand, *viâ* Cape of Good Hope, 4 months, 14,000 miles. British manufactures. Steam 2 months | 9 vessels per annum. |
| | To England *viâ* Cape Horn, 4 months, 14,000 miles. Copper, wool, timber. | 5 vessels per annum. |
| With Sydney | 10 days from Wellington, 1200 miles. British manufactures and stock from Sydney. Flax, barley, pork, timber to Sydney. | 3 vessels per month. |
| With Hobart Town | 15 days from Wellington, 1300 miles. British manufactures and flour. | 1 vessel per month. |
| With Hong Kong | 2 months, 6000 miles, *viâ* Pacific or Torres Straits | Occasionally from China. Scarcely ever to China. |
| With United States | 4 months, 14,000 miles, American manufactures | 5 vessels from United States per annum. |
| With California | $2\frac{1}{2}$ months, 8000 miles. | Occasionally to California. |
| With Tahiti | 30 days sail, 2300 miles, 11 days steam | No trade at present. |
| And on to Panama | 22 days steam, 4500 miles | |
| And on to England | 20 days steam, 4600 miles | |

There is no trade at present with South America or with India.

In 1852 regular steam communication was first established between England and Australia; in screw steamers once every two months, *viâ* the Cape of Good Hope, West Australia, South Australia, and Victoria to Sydney; expected to be done in two months from England. But as yet it does not extend to New Zealand, which is still therefore dependent on occasional traders for its mails. I do not think there is any one greater boon (after the men and money necessary for its defence) that the Imperial Government could confer on New Zealand than steam communication with Sydney. And I think that a plan of communication might be arranged, by which the same steamer would meet the bimonthly mails at Sydney, and also communicate monthly between the principal settlements in the colony, thereby doing the double duty of conveying the mails from England, and establishing that intercommunication between the settlements which is now so much required, and for which New Zealand is so peculiarly well adapted. According to the Admiralty statement in the "Blue Book," 1846, the annual cost of a steamer of the size of the "Volcano" is about 5600*l.*, which would be in New Zealand, allowing for increased expenses, about 7000*l.*

9. RECAPITULATION.

## SECT. IX.—RECAPITULATION.

These are the principal characteristics which are to be borne in mind, in considering all points connected with New Zealand.

1. *Long narrow islands* with numerous small harbours and rivers.

2. *Long narrow mountain ranges* covered with forests and divided by flat grassy valleys, but all very difficult of passage for foot passengers, even by the footpaths.

3. The *six British Settlements* planted on the coast with a small town and a little county of civilisation round each, and containing altogether 20,000 British settlers.

4. All the rest of the *North Island,* filled with 80,000 savages, settled in villages about the coast and rivers. All the rest of the *Middle Island* almost uninhabited.

5. The *communication* about the islands (by small vessels) constant, with Sydney once a month, with England three or four times a year. Carriage-roads for a few miles only about the British settlements, foot-paths through the rest of the country.

6. A British population slowly increasing, and stock farming spreading fast; agriculture increasing slowly; a native population slowly decreasing.

7. Want of defence against the natives.

8. The summary of the latest statistics of the Colony, contained in the following table :

1. POPULATION, 1851.*

| | British. | Natives. |
|---|---|---|
| Settlement of Auckland | 9000 | |
| „ Wellington | 5000 | |
| „ Nelson | 3000 | |
| „ New Plymouth | 1500 | |
| „ Canterbury | 2500 | |
| „ Otago | 1000 | |
| Remainder | 1000 | |
| Total | 23,000 | 90,000 |

2. EXTENT.

| | British. Acres. | Native. Acres. | Total. Acres. |
|---|---|---|---|
| North Island | 1,000,000 | 30,000,000 | 31,000,000 |
| Middle and Southern | 40,000,000 | 7,000,000 | 47,000,000 |
| Total | 41,000,000 | 37,000,000 | 78,000,000 |

3. PRODUCTIONS, 1850.

Wheat, maize, and other grain (total quantity of land under cultivation in all the settlements by British settlers, 30,000 acres).

Sheep, 100,000; horned cattle, 30,000; horses, 2000; pigs, &c.

Flax, pine timber, copper, sulphur, iron, and coal.

* M. Martin and Colonial Returns.

9. RECAPITULATION.

4. EXPORTS AND IMPORTS, 1848-50.*

*Imports.*

| | South. | North. |
|---|---|---|
| Clothes, &c. . . | £12,000 | |
| Flour, &c. . . . | 5,000 | |
| Iron, &c. . . | 4,000 | |
| Stock . . . . | 40,000 | |
| Provisions . . | 10,000 | |
| Spirits . . . | 8,000 | |
| | £79,000 | 140,000 |

| | | |
|---|---|---|
| Total | British (manufactures) | £52,000 |
| | Colonial (stock and raw produce) . . . | 170,000 |
| | Foreign . . . | 3,000 |
| | Total . . | £225,000 |

*Exports.*

| | South. | North. |
|---|---|---|
| Whale oil and bone | £14,000 | |
| Wool . . . | 8,000 | |
| Copper ore . . | —— | |
| Timber . . . | —— | |
| | £22,000 | 20,000 |

| | | |
|---|---|---|
| Total | Britain . . . | £16,000 |
| | Colonies . . . | 22,000 |
| | Foreign . . . | 5,000 |
| | Total . . | £43,000 |

5. SHIPPING, 1848.

| | No. of ships. |
|---|---|
| To and from Great Britain . . . . | 10 per annum |
| „ British colonies . . . . | 90 „ |
| „ Foreign countries . . . | 40 „ |
| Small coasting vessels belonging to the colony | 200 |

6. REVENUE AND EXPENDITURE, 1848.†

*Revenue.*

| | North. | South. |
|---|---|---|
| From colony . . | £28,000 | £19,000 |
| Aid from Brit. Parl. | 23,000 | 28,000 |
| | 51,000 | 47,000 |
| Total . . | £98,000 | |

*Expenditure.*

| | North. | South. |
|---|---|---|
| Offices of Governmt. | £36,000 | £26,000 |
| Public works . . | 15,000 | 19,000 |
| | 51,000 | 45,000 |
| Total . . | £96,000 | |

| | North. | South. |
|---|---|---|
| Military expenditure of Great Britain in 1848 ‡ . | £90,000 | £65,000 |
| Total . . | £155,000 | |

* Martin's Cols. and B.B. † From B.B. ‡ Martin's Cols.

END OF PART I.

# PART II.

## GENERAL HISTORY AND NORTHERN CAMPAIGNS.

1. GENERAL HISTORY.

### SECT. I.—GENERAL HISTORY TO 1844.

1642. *First visit of a European, *Tasman,* a Dutch naval officer, sighted, but did not land.

1769. *Captain Cook's* first visit. He took possession for Great Britain; same year *De Surville* (French) visited New Zealand, and also took possession.

1772. *Captain Cook's* second voyage, in which he paid three visits to New Zealand.

1777. *Captain Cook's* third voyage, in which he visited New Zealand.

1791. *Captain Vancouver* visited New Zealand; and about this time the whalers began to frequent the coast.

1814. *Rev. Mr. Marsden,* a Church of England missionary at Sydney, established a mission at the Bay of Islands; and Governor Macquarrie, of New South Wales, appointed Mr. Kendal as a British magistrate at same place.

1822. *Wesleyan Mission* established at Hokianga. For ten years about this time, the chief, *Hongi,* was the head man in the country all about the Bay of Islands, and carried his wars as far south as Lake Taupo; and the natives began to obtain fire-arms.

1831. In consequence of the quarrels between the whalers and natives, the natives of the Bay of Islands petitioned Great Britain for protection (at the suggestion of the missionaries).

1833. In consequence, *Mr. Busby* was sent by the governor of New South Wales to the
1834. Bay of Islands as Resident; and a sort of *protectorate* was established, the
1835. national flag of New Zealand being acknowledged by Great Britain, and a declaration of independence signed by the chiefs at the Bay of Islands, under
1836. the direction of the missionaries. But soon after some of the missionaries petitioned for greater protection, the native rule being too weak. Speculators from Sydney began to purchase vast tracts of land, twice and three times over,
1838. comprising altogether more than the whole islands. The English at the Bay of Islands formed themselves into a government, owing to the want of law, there being then about two thousand English in all New Zealand.

1840. When, in consequence of the representation of all these things, the British Government sent out *Captain Hobson, R.N.,* in January, 1840, who, in accordance with his instructions, held a meeting of the natives at the Bay of Islands, and got the signature of the chiefs of that part to the *treaty of Waitangi,* which gave over the sovereignty and the priority of the purchase of land to the Crown of England. There was a strong discussion about this treaty; but no force was used, and many

* M. Martin's "British Colonies."

chiefs in all parts of New Zealand afterwards signed it. The sovereignty of the Crown was declared, and *has never been denied by any large party among the natives.* 1. GENERAL HISTORY.

*A Royal Charter* was sent out, constituting New Zealand a British colony. Captain Hobson first established his seat of government at the Bay of Islands; but in November, 1840, moved it to *Auckland*, where he purchased land from the natives, and resold it to the speculators, shop-keepers, and settlers, who flocked in great numbers from Sydney. 1840.

In August, 1839, the *Tory* arrived at Port Nicholson, in Cook's Straits, with *Colonel Wakefield*, the agent of the *New Zealand Company*, who sent him out without the consent of the British Government, and he, in accordance with his instructions, made treaties with the natives, and got the signatures of some of the chiefs of the tribes on both sides of Cook's Straits to the purchase of a tract of country extending from a line drawn across the island, at about latitude 39°, to a line across the middle island, at about latitude 42°. 1839.

In January, the settlers arrived from England, and the town of *Wellington* was established. But some of the natives began immediately to repudiate their bargain with Colonel Wakefield, and would only allow the settlers to occupy some land about Port Nicholson; and had frequent quarrels about parts of even that: and the purchase of the Wellington block was not satisfactorily concluded till 1848. 1840.

In March, the first *New Plymouth* settlers arrived at that place. The Plymouth Company in England bought 50,000 acres from the New Zealand Company, and their surveyor, Mr. Carrington, selected the site. But the natives there began immediately to repudiate their bargain with the New Zealand Company, and would only allow the settlers to occupy about 3,000 acres: and the purchase of the whole 50,000 has never yet been satisfactorily concluded. 1841.

In the autumn of this year *Nelson* was founded. The settlers bought land from the New Zealand Company in England, and *Captain A. Wakefield* was sent out to select a site, and fixed it at Wakatu, in Blind Bay. But the natives of the place repudiated their bargain with the New Zealand Company; and the purchase was not satisfactorily concluded till 1846: however, being few, they made no hostile opposition. But when the Nelson settlers proposed to occupy the *Wairau* valley as part of their purchase from the company, then some of the tribes on the north side of Cook's Straits, who claimed a right over it, came over and opposed the occupation. 1841.

In this year also the first settlers occupied *Wanganui* (or *Petre*), as part of the Wellington settlement; but the natives there also repudiated their bargain with Colonel Wakefield, and would only allow the settlers to occupy the site of the town: and the purchase was not satisfactorily concluded till 1848. 1841.

It appears evident, from the opposition of so many of the natives at these four different settlements commencing immediately on their establishment, that Colonel Wakefield did not take sufficient pains to satisfy the natives in purchasing such an immense tract as he endeavoured to do; for it evidently requires a long time and great pains to purchase land from natives, such as the New Zealanders have been described to be in the former part of this paper. But he continually refused to have further treaty with them, and the dissatisfied part of the natives continually opposed the settlers endeavouring to locate themselves; and it finally ended in a war at Wellington in 1846, and at Wanganui in 1847.

In June this year, the colonial government at Auckland passed a law, establishing a commission for inquiring into the purchases of land by British subjects previous 1841.

I. GENERAL HISTORY. to the treaty of *Waitangi*. All the purchases in the north were examined before this commission: some were rejected, and no person was allowed to retain more than 2,560 acres. There was no serious or continued opposition on the part of the natives in the north to the purchases of the Crown, or, after the decision of the commission, to the other purchases. The purchases of the New Zealand Company were also examined before the commission.

1840. In May, 1840,* Major Bunbury and 100 men, 80th regiment, arrived from Sydney, being the first British troops that arrived in New Zealand. Lieutenant Lugard, R. E. followed them. These troops were sent on the application of Captain Hobson. A detachment of them were stationed at the first capital, Russell, in a small temporary house; and the remainder at the second capital, Auckland. In September, 1840, another company was sent from Sydney to Auckland.

Now here appears to me to have been one of the most serious errors in the formation of the Colony, and which assisted materially in bringing about its great difficulties. When the Home Government had finally decided that New Zealand *should* be colonised, they should have taken care that on the first establishment of military force in it the strength of that force should have been amply sufficient to overawe the natives; they should have been well equipped for the peculiar service, and well provided with means for establishing themselves in a defensible position, such as would serve as a citadel for the capital. At that time, as Major Bunbury well expressed it, the natives had "an almost superstitious dread of encountering the military." † "The least check would dissolve the charm;" and "the natives are well provided with muskets and ammunition;" and "the efforts of the Government and clergy tending to allay the jealousy and rivalry of tribes," would also, by combining them more together, "expose the European population to greater danger," and further, "the nature of the service requires an equipment somewhat different from that required by an ordinary detachment of infantry;" he further volunteers "to make a descent on any part of the coast with 100 men;" that is, properly equipped. I do not think he would have volunteered to march into the interior with 500 men followed by the ordinary baggage-train of a regular force.

But New Zealand was yet of small importance in the British empire, and its necessities and wants were not understood: instead of this proper equipment and strength, they were sent one company at a time, and without means to form a military post. Captain Lugard states "he had about twenty-five men from the 80th as artificers;" he was obliged to build "a rustic block-house at Russell, temporary, and not bullet-proof," owing to "the extreme paucity of means." ‡

1841. Again, at Auckland, "we had no assistance from Sydney in the shape of materials. I had to make shingles and bricks—fell and saw timber—burn shells for lime—collect scoria for building—and none but soldiers to work with, and only hand-carts and a boat. I had no authority to purchase materials or employ civilians." It is wonderful what a good, substantial barrack he left behind him with such

1842. materials to work with. In February, 1842, Captain (then Lieutenant) Bennett, R. E., relieved Lieutenant Lugard.

Captain Hobson saw the necessity of having a proper military force; he had asked for it in 1839, and it was refused, or, at least, sent in small numbers as above described.

If the home Government, upon receiving such reports as the above from the

* Capt. Lugard, R.E. † Major Bunbury, B. B., 1844.
‡ Letter from Capt. Lugard, 1842.

colony, had sent out, in 1842, a regiment specially equipped for the service, with a train of suitable artillery, and a force of sappers well supplied with tools and materials, and ordered the whole force to be trained for their peculiar service, they would have saved the strength of two and a half regiments they were obliged to send at last, and the moral effect of British power would have been undisturbed to this day. The weakness of the British power, in this respect, is shown in the first native disturbance that the Government took part in—*Tauranga*, in 1842. 1. GENERAL HISTORY.

## SECT. II.—TAURANGA.

### *The Tauranga Campaign in* 1842.

There was no actual fighting in this affair, but it is considered worthy of record, from its affording an example of the character of the natives, and of their fortified villages, or *pahs*. This was the first occasion on which the troops were called out :—* 2. TAURANGA.

Two native tribes, at *Tauranga and Maketu*, in the Bay of Plenty, 130 miles S. E. of Auckland, fought upon an ancient quarrel; and the acting Governor, Mr. Shortland, wished to interfere to put down such wars, and obtained a pretext, from the two tribes having respectively seized two boats belonging to Englishmen trading there; so, being at *Tauranga* himself, he sent the colonial vessel, a brig of 200 tons, called the *Victoria*, to Auckland, with orders to Major Bunbury, 80th regiment, commanding there; who thereupon embarked all his available men (about forty), and the following ordnance and ammunition :— 1842.

| | |
|---|---|
| Two 18-pounder cannonades<br>100 rounds shot<br>Fifty rounds canister | From H.M.S. *Tortoise*, with seamen and marines. |
| 7,100 musket-ball cartridges. | |
| 126 round shot<br>125 grape and canister | With one 4-pounder iron gun. |
| And some engineers' stores. | |

Lieutenant Bennett, R. E., then commanding engineer in New Zealand, accompanied the expedition.

Having arrived at *Tauranga*, the force disembarked at *Monganui*, between *Tauranga* and *Maketu*, and encamped. The natives objected to the right of the British to interfere in wars between themselves; and the acting Governor, finding that the expediency of interfering was a very doubtful question, and that he had a very small force, effected some kind of mediation, and withdrew the troops. On this occasion the natives ate some of their native prisoners, being the last time such a thing has been known to have been done in New Zealand.

Lieutenant Bennett, R. E., took the opportunity of examining some of the native pahs, and made a report thereon to the Inspector-General of Fortifications, which report contains so exact and good an account of them, and of the means necessary for their attack, that it is herewith given in full :—

### *Report on the Pahs of New Zealand.*

The strength of the pahs of New Zealand consists principally in the choice of position.†

They are generally situated on peninsular points, with three sides inaccessible; being steeply scarped towards the sea, usually from 50 to 60 feet in height, and

* B.B. 1845. Lieut. Bennett's dispatch, Jan. 1843.

† See plans to article *Pah*, showing Heki's Pah, vol. ii. Aide Mem. Mil. Sciences.

2. TAURANGA. 1842.

palisaded at top: the depth of water round them being (generally) such as to prevent any vessel larger than six or eight tons approaching them within range of field-guns; I consider the attack of these sides, except by surprise, impracticable; the fourth side is always cut off by a deep ditch having steep scarps from 20 to 30 feet in height, and counterscarps from 6 to 16 feet; the nature of the soil being generally a stiff clay, or soft sandstone, retains the slope of 60°.

The terreplein, from 20 to 30 feet broad, has a strong palisade in front, or the palisade is placed above the scarp with a low parapet and banquette, and the whole of the interior of the pah is intersected in every direction by fences, each hut being fenced around. These interior defences, though low, if not destroyed before the entrance of the troops, must entangle and confuse them, and totally prevent the use of the bayonet. The ditches are also flanked by a strong palisade.

In addition to the principal pah, there is also frequently an outer work with a low ditch palisaded in front, and commanded by the main work; and should one part of the pah be considered weaker than another, it is strengthened by a double palisade, 3 feet apart, with embrasures left in the outer one at the level of the ground, and a trench cut inside to afford cover.

In short, the pahs assume every description of defence of this nature, of which they are capable, and are sometimes strengthened by even three successive rows of palisades.

The palisades themselves consist of large trees about 1 foot in diameter, roughly hewn, and placed 6 or 8 feet apart, and afford safe cover for a man; they are from 12 to 20 feet in height, rudely ornamented at top; between these posts long stakes, from 8 to 10 feet high, and 1½ inch diameter, and nearly tangent to each other, are strongly bound together; or, if greater strength is required, rough three-sided stakes about 9 inches perimeter are used.

Should the pah not be situated on a peninsula, its front consists of one steep side towards the sea, with generally a deep and wide gully on each flank, and the gorge is protected by a deep ditch, as before described.

The section of the pah of *Temutu* exemplifies the usual defences, but the natives evince considerable military knowledge, and I observed that several of their pahs had their counterscarps excavated, having small openings like embrasures. These, I am told, are used for keeping potatoes, and I cannot learn that they have ever been used for defence.

In illustration of their military knowledge, I may say that when I was ordered to prepare a plan of attack of the Pah of *Maketu*, I consulted the chief *Tupaia*, of *Otumaiti* pah: he immediately sat down on the sand and erected a model of the pah and surrounding country, giving me the distances and command that each hill had over the pah and each other, and pointed out how it might be approached with safety. The plan I made from his model I was subsequently able to compare on the spot, and found his plan and ideas very correct.

The number of men the pahs would contain varies from 300 to 800, and they possess a large supply of potatoes and *kumera* (sweet potatoe) in holes excavated for the purpose. They have also an abundance of muskets and ammunition, the former very good, and nearly all double-barrelled: the latter made up into cartridges; and each man is supplied with a good cartouche-box.

They have also their tomahawks for close quarters; I may add that they are an exceedingly active and warlike race, and few of them without the experience of several fights.

I have been informed that the pahs in the interior of the country are

2. TAURANGA. 1842.

constructed on the same system, detached hills, or hills on the extremity of a ridge, being the site usually chosen.

What I have said relative to the choice of position of their pahs relates only to that arm against which they have hitherto had to contend—the musket. But I have seen no pah which was not commanded at distances varying from 200 to 600 yards; consequently the method of attack is simple and certain.

A couple of 12-pounder $4\frac{2}{5}$ inch brass howitzers to break down the palisades, and with a few carcases to set fire to the huts and interior fencing already described, places the strongest pah at the mercy of a few men; but without these means, I conceive that the attack of a strong pah must always be attended with considerable loss to the assailants.

The howitzers must be light, as they will have to be landed generally on a beach with a surf, and will have to be got up a height of 50 or 60 feet to be placed in position. A few rounds of grape and canister for the same guns would also be necessary, and two or three Coehorn mortars and some hand grenades exceedingly useful.

From the want of knowledge of gunnery by the soldiers of the line, it will be necessary that a few artillery men (or sappers and miners well instructed in the use of howitzers, and method of making up carcases) should accompany them; the latter, I venture to suggest, would be the most useful in this colony, as their labour as mechanics would be very valuable in the erection of ordnance and barrack buildings in New Zealand, where the price of such labour is high, and the mechanics of the detachment (of the line) so few and indifferent.

Should it eventually be found necessary to disarm any tribe on account of their continued wars and cannibalism, I conceive that the ordnance above specified, with three companies of the line, would be sufficient to surround the pahs and force the surrender of their arms.

I trust I shall be excused for making the above suggestions, as the insufficiency of our means, from want of ordnance and gunners when the attack of Meketu pah was contemplated, was severely felt, and was only overcome by the accidental presence of H.M. Store-ship "Tortoise," and the assistance they afforded; without such assistance I do not consider that our means (*sixty-five infantry*) were such as to justify an attack, where a repulse must be attended with such serious consequences, in destroying the wholesome dread they at present have of British soldiers.

(Signed) GEORGE BENNETT,
Lieut. Royal Engineers, commanding.

*Feb.* 10, 1843.

The subsequent experience of the pahs in the interior corresponds exactly with his description. *Their strength consists in the site.* They are invariably placed on the ends of narrow spurs overlooking the sea, the rivers, or the plains, and have all the same kind of ditches and palisades; and in addition to the difficulty he mentions, of having to provide artillery to take them, must be added the greater difficulty, not contemplated by him at that time, of having to transport the artillery through the thickly-wooded hills; for he thought only of pahs on the sea coast, accessible to shipping; a march of even ten miles inland, in such a country, would make the greatest difference in his plan of attack; besides, the pahs afterwards attacked by the British troops were expressly constructed against them, and were much stronger in the palisading than those he describes, and required heavier artillery. Captain Marlow considered that 12-pounder guns and $5\frac{1}{2}$ inch howitzers would be required to make a breach in *Ohaiawai* pah. It does

2. TAURANGA. 1842.

not appear that Lieutenant Bennett's recommendations were attended to, for no equipment was provided until the difficulties had arrived at too great a height for them to be of the use expected.

In September, 1842, Captain Hobson died in New Zealand, and Captain Fitzroy, R.N., succeeded him. In the interval before Captain Fitzroy arrived, the Colonial Secretary, Mr. Shortland, acted as governor.

The great mistake made by Captain Hobson at the commencement of the colony was the selection of the site for the capital. If the whole British strength had been concentrated at Wellington, it would have been sufficiently powerful to have overawed the natives there: the New Zealand Company fell also into this fault of scattering their forces. Both Company and Government thought to colonise all New Zealand at once, totally forgetting the natives; and to protect these scattered settlements required a greater power in men and money than the Home Government chose to allow. Indeed, it was not altogether Captain Hobson's fault in the choice of a capital; it was the want of concert between the Home Government and the Company, which placed the Governor and the Company rather in opposition in New Zealand than in conjunction. As it has turned out, the formation of other settlements in the middle island have established Cook's Straits to be, what a glance at the map shows it to be at once, the proper site for the capital of New Zealand.

Captain Fitzroy arrived in November, 1843. Captain Hobson had been somewhat aware of the strength and character of the natives; and if the Home Government had but sufficiently supported him with men and money, he might have saved the future wars. But Captain Fitzroy came with the predetermination of governing the natives by moral force.* He refused to use a military force from the commencement, and delayed asking for it until the moral effect of it had evaporated, and even then got rid of it again as soon as he dared. With the most honourable high-minded desires for the benefit of both British and natives, he fell into the same error as the early missionaries did—of considering the natives as a semi-civilised race, which could be raised and amalgamated with the Europeans; and under his too lenient government the troubles with the natives, which might have been prevented in Captain Hobson's time, grew to such a head that three years' war was required to put them down.

He found the colony languishing for want of money, and the natives growing more and more outrageous: in the south they had come to open fight with the settlers. After the experience already obtained, and the reports that had been made, it is now evident that a strong military force was more required than ever. The first difficulty he had to meet was the massacre of *Wairau*.

### SECT. III.—WAIRAU.

3. WAIRAU.

†After the establishment of Nelson in 1842, the settlers of that district began to spread towards the *Wairau* valley, which was understood to have been purchased by Colonel Wakefield in his first purchase; but in March, 1843, the chief, *Rauperaha*, being in Nelson, protested against this purchase, and some threats were exchanged between him and Captain Wakefield, the Company's agent at Nelson. Captain Wakefield, feeling confident in the justness of the Company's claim, sent surveyors into the Wairau, which the chiefs *Rauperaha* and *Rangiheata*, considering as the act of taking possession, opposed by burning the hut of the

* Nelson petition, 1845.

† B. B. 1844-45, Nelson petition. Martin's Col.

surveyors; upon learning which Captain Wakefield was persuaded to endeavour to seize the chiefs. It was thought to be a favourable opportunity for teaching the savages to respect English law. He took out a regular warrant against *Rauperaha*, and proceeded with several of the principal gentlemen of the settlement and about forty labourers, armed with muskets, on board the colonial brig "Victoria," from Nelson to the *Wairau*, in June, 1843, and marched five or six miles inland, to where the natives were encamped, expecting to be allowed to take the chief without resistance. There were about 100 natives. After some peaceable discussion, the magistrate of the party made some strong demonstration of seizing *Rauperaha*, which led to a sort of rush on both sides: a gun was fired from the British side,—the natives returned it;—a sort of fight began, and the labourers, being totally unprepared for, and unaccustomed to, anything of the kind, got into confusion and scattered each for himself. Nearly all the gentlemen leaders were taken and killed immediately, in what we should call cold blood.

3. WAIRAU. 1843.

Now the disputes concerning land with these natives cannot be considered, upon the point of abstract law, as to whether the Company had a legal right to the land or not; it should rather be considered, whether the Company had obtained the consent of the majority of the native owners to the purchase, and whether they had the force to hold their land against the remainder. Now, there were doubts at the time about the purchase of this land, and the land commissioners were investigating it at Wellington: they were expected over at *Wairau*, and the natives would have waited at least to hear their decision. Moreover, it might have been fully expected that the natives would have resisted; for they had been very much excited upon this land question on both sides of Cook's Straits for a year or two before: therefore, I do not think Captain Wakefield was justified in using force; indeed, he seems to have had doubts about it himself. But even if he had been justified, it was an act of the greatest rashness to attempt to arrest a chief in the midst of his own people with such a force. Knowing the savage character and the excited state of them, he should have had a band of trained men sufficient to overawe them; a smaller number of whalers would perhaps have put down a greater number of natives; but no body of undisciplined English labourers, acting without concert—even without leaders—could make any stand against savages, whose very appearance and manners they had an ignorant fear of; and if New Zealand had been left to the defence of her settlers, notwithstanding the individual bravery of the English colonist, as a body, there would have been no better result than *Wairau*.

The effect of this the first successful stand, made by the natives against the British, was felt and magnified in the native manner through the country, and gave a new confidence to all those dissatisfied natives who before had been deterred by fear from open hostility against the British rule; and this effect was increased by the conduct of Governor Fitzroy, in pardoning and making friends with the chiefs who did the deed before even they had acknowledged their fault or expressed any regret for it.

He might surely have shown in some decided manner his condemnation of the deed, even if he did not feel himself strong enough to punish it.

Immediately afterwards, he let off another native chief, who had committed some strong breach of English law at Auckland. Then he had to deal with the disturbances at the Bay of Islands, which fully proved to him the necessity of armed interference.

Even now at this time, before the destruction of Kororarika, if Captain Fitzroy

3. WAIRAU. 1843.

had determined upon using force, he might have saved a great part of the subsequent wars. After the *Wairau*, the time had gone by when the natives could be kept in order with the small force proposed by Major Bunbury. But still the prestige of the troops was untouched. The best evidence of the mistake of the doctrine of moral force is in the annual report of the Chief Protector of Aborigines (an officer established by Governor Fitzroy), in which he congratulates the Governor (July, 1844,) on the tranquillity of the colony, and the prospect of permanent peace and security, the whole country from north to south being then ripe for explosion. Next year the wars began, and continued for two years. And, at the same time, most of Mr. Clarke's letters go to show the necessity he felt of having a strong police in the country, and the impossibility of preventing wars among the natives by moral force alone.*

### SECT. IV.—KORORARIKA.

*The Destruction of Kororarika.*†

4. KORORARIKA.

The original settlers had continued to occupy their settlement at the Bay of Islands, which was situated on the shores of the bay, and called *Kororarika*. They consisted chiefly of whalers, and persons engaged in trading between the natives and the whalers. There had always been a lawless, half-civilised system of dealing carried on there by the Europeans, which the natives were partly obliged and partly willing to put up with, being gratified with the great trade of the whalers; and also because their supremacy and their customs were never very violently interfered with. But when the British Government took possession, and a regular magistrate came to be established at *Kororarika*, and a regular custom-house, the native chiefs found that they had lost their supremacy, and that a new and unknown law was in force in place of their old customs; and moreover that they had lost their trade with the whalers, who deserted the harbour when the customs' duties were established: and they began to be dissatisfied, and to believe in the reports of some of them (fomented by discontented Europeans)—that the British Government intended their destruction. There was no dispute about land; very little had been purchased there;—it was the inevitable discontent of the savage at the sudden breaking down of his old laws and customs by the introduction of civilised law.

If the civil power had been at that time sufficiently supported by a military force to overawe both natives and settlers, probably no outbreak would have taken place there any more than at Auckland. But disputes between natives and settlers occurred from time to time; and the decisions of the police magistrate, being totally without force to support them, were not respected by either party: the natives took the law into their own hands, and from one aggression to another, finally in July, 1844—a body of them under the command of *Hone Heki*, a chief of the neighbourhood—pillaged part of the town, and "carried into effect that which they had long been threatening—*the destruction of the Government flagstaff*, because, they said, it prevented the American vessels coming into the harbour."—*New Zealander, June* 7, 1845.

*Heki* was not himself a chief of great rank; but he had married the daughter of the great *Hongi*, and was noted as a clever daring man, and was one of the losers by the desertion of the whale-ships.

The Governor immediately sent to Sydney and Hobart Town for troops, being

* B. B. 1845, 46.   † B. B. Local papers. Nelson petition.

the first time that he had demanded them; and in the first week in August a merchant vessel arrived at the Bay of Islands with 160 men of the 99th Regiment from Sydney, and on the 24th August the Governor arrived from Auckland with a detachment of the 96th Regiment under Lieutenant-Colonel Hulme, and with H.M.S. "Hazard," Capt. Robertson, and the colonial brig "Victoria." The Governor held a meeting of the natives, spoke to them, and took off the customs duties. This, and the appearance of force, brought even *Heki* into terms of friendship. *And the troops returned immediately to Sydney!* instead of establishing a strong military post at *Kororarika*. But the bad passions of the savages were rather stimulated than allayed by the too great leniency and confidence of the Governor. In October and in January further disputes occurred between the powerless civil power and the settlers and natives; in which the natives took the law again into their own hands, and *Heki* again cut down the flagstaff. And the Governor issued proclamations for his apprehension. And between 16th January and 6th March there arrived at the Bay of Islands H.M.S. "Hazard," the "Victoria," two subalterns and 50 men of the 96th Regiment,* from Auckland. But the excitement and self-confidence of the natives had been by that time allowed to get to too great a height to fear such a force. The flagstaff was cut down a third time, and the town of *Kororarika* attacked by 1,100 natives under *Heki*, on the 11th March. The town, as will be seen by reference to the accompanying map, extends along the beach for about a mile, with a hill at each promontory. The hill on the south side is about 200 feet high; and on it two block-houses were placed, one on the top, and one below, closer to the houses. These block-houses were put up by Captain Bennett, R.E., soon after the Government was established in the colony. There were twenty men in these block-houses, and the remaining thirty in a house in the town. They were one story high, twenty feet square, of solid square timbers.†

4. KORORARIKA.

1844.
1845.

The natives having stated that they intended to attack the town, Captain Robertson posted himself with 150 men from the "Hazard," and a field piece, at the hill on the north side of the town at daylight on the 11th. He was immediately attacked by 200 natives, whom he kept at bay. About the same time Ensign Campbell, who commanded the upper block-house, was absent with his men 200 yards from his block-house, making intrenchments: the natives surprised the block-house; and he retreated to the lower one. Upon this, Captain Robertson's party spiked their gun, and fell back; and the whole force, together with the inhabitants of the place, some of whom were armed, and assisted in the defence, occupied the lower block-house and a house of Mr. Polack's near it, which was stockaded; and, with the assistance of the guns of H.M.S. "Hazard," defended themselves for three hours against the natives, who fired from the neighbouring broken ground. At ten o'clock the magazine of powder in Mr. Polack's house exploded by some accident, and destroyed the house. Then the whole force and inhabitants went on board the vessels in the harbour; and on the following day the natives pillaged the town, without injuring the inhabitants, some of whom were still busy taking off their goods to the vessels. The vessels and inhabitants proceeded to Auckland.‡

There were killed on this occasion—

| Naval. | Military. |
|---|---|
| 6 men. | 4 men. |

Captain Robertson was wounded severely.

* 20 men. U. S. Journ., Dec. 1847. † New Zr., June, 1845. Bishop Selwyn's Journ.
‡ Dispatches of Capt. Marlow, Oct. 1846, Lieut. Phillpotts, R.N., Lieut. Barclay and Ens. Campbell, 96th. Mr. Beckham, Pol. Mag. Bp. Selwyn.

4. KORORARIKA. 1844. It was impossible to defend such a straggling town, with 200 men and only two block-houses, so situated. If Ensign Campbell had not been surprised at the upper block-house, and the magazine had not exploded, they might have held the posts they occupied; but it would have required half-a-dozen block-houses to have protected the town from pillage with that force. That body of men could not have prevented, by any skirmishing, 1100 natives, fighting after their manner under cover, natural and artificial, from destroying part of a village three-quarters of a mile in length. But they might have held their posts; and the posts were lost by the surprise of the block-house.

Great praise is given in all the dispatches to Captain Robertson, R.N., of the "Hazard," for his bravery; and the kindness and attention of Bishop Selwyn is highly spoken of; and also of Captain Mackeevor, of the United States frigate "St. Louis."

After the destruction of *Kororarika*, Governor Fitzroy came to the resolution he should have come to a year before—of attacking *Heki* with a strong force. His want of decision previous to this affair was proved to be a mistake by the letters of *Heki* and *Kawiti*, after *Kororarika*, which show a kind of prevarication, as if they were still half-doubtful of their success, and half afraid of British power.

He then began to ask earnestly for troops from Sydney (that being the head-quarters of this military division of our colonial empire); and he raised the militia, which he had before refused to do, on the ground that the colony could not afford it, and that undisciplined men with arms in their houses would do more harm than good. But bodies of English settlers, partially disciplined for a few years, would have been of very great use, well supported by troops, especially as the settlers everywhere were anxious to enrol themselves. And the expense might have been borne in the first instance by the Home Government. Such was the alarm and the ignorance and fear of the settlers concerning the natives, that it was believed *Heki* was coming to attack Auckland.* The barracks on Point Britomart were intrenched and two blockhouses built; (there were already some stone barracks;) 300 militia were armed, and picquets stationed about the town. But there were no defences capable of protecting the town; if there had been no troops, *Heki* would probably have appeared before it, and it would have shared the fate of *Kororarika*, and been deserted. Many did leave.

So the third expedition against *Heki* commenced.

March 23. H.M.S. "North Star" arrived from Sydney with 250 men, 58th.

April 21. The barque "Slain's Castle" arrived from Sydney with 200 men, 58th (these troops were intended to have been in time for Kororarika, but were delayed in Sydney).

April 23. These vessels and others sailed to the Bay of Islands with part of the 58th and a detachment of the 96th.

### SECT. V.—OKAIHU.

*Description of Country at the Bay of Islands.*†

5. OKAIHU. 1845. As the military operations now began to be extensive, and to extend into the interior, it is necessary here to give some idea of the country and state of the natives of those parts.

The main range of hills runs down the centre of this part of the islands,

* Lieut. Balneavis, 58th Regt. Local papers. Capt. Fitzroy's pamphlet, 1847.
† Martin's Col.

dividing the waters of *Hokianga* from the waters of the Bay. It is about 1000 feet high on the average. On the *Hokianga* side almost the whole country consists of steep ridges, deep valleys, with flat alluvial bottoms, and all covered with thick *Kauri* forest. On the side of the Bay the hills stretch away towards the coast in the level plateaus with steep sides, that have been already described, and as they get nearer the coast the forest becomes more confined to the ravines, and the plateaus are covered with fern and low shrubs; the hills run right down to the promontories, forming bluff points on the coast, with low flat valleys in between. Those arms of the sea which form the capacious Bay are the outlets of such flat valleys, and the sides of them are steep and covered with wood. But this plateau fern land is almost as impracticable for military operations as any other; the high fern and shrubs prevent even the settler from leaving the beaten track, and that track, with the exception of a few cart-tracks worked by the missionaries, consists of simply the native foot-paths, following generally the most difficult line for a traveller; and the ravines of these plateaus are very frequent and very abrupt, and generally wooded.

5. OKAIHU. 1845.

As the head-quarters of both Church and Wesleyan missions were in this part, there was more English cultivation and establishments at that time than in most parts of New Zealand. Besides the whaling town of *Kororarika* (now, however, in ruins), there was the Church mission station at *Waimate*, quite a village among fields, and several bush farms of the missionaries in other places.

Through all the native wars, and through all the British wars, these missionary establishments continued untouched, and the missionaries were allowed to pass to and fro amongst friends and enemies unharmed.

*The natives were now pretty much divided into two parties; *Tomati-Waka-Nene*, a chief of the *Ngatihao* tribe, may be considered as the head of the Government party: he had constantly supported the British side since the treaty of *Waitangi*, and now openly opposed *Heki; Pomare, Kawiti*, and some others, sided with *Heki*. These divisions of the natives, both in this war as in all other British wars in New Zealand, have been produced partly by real desire towards British rule, and partly by their old family feuds. *Waka* and *Heki* had been old enemies. Although these tribes were so much opposed to each other, their lands and pahs were intermixed; they had been fighting some years before, and each party had built *fighting pahs*, as they call them, on the occasion. These pahs were built sometimes on their own land, sometimes on their enemy's, and they would occupy them for months without coming to a fight, until some chance brought on an engagement. *Heki* appears to have followed this mode of fighting in all his wars with the British, but against us he built much stronger pahs than they were accustomed to build in their own wars. The natives, both allies and enemies, were generally found to be well armed with guns, chiefly double-barrelled, and the enemy well supplied with ammunition; our allies were supplied by Government. Arms and ammunition had been the favourite barter with New Zealanders for pigs and potatoes from the first appearance of whalers among them; and the sale increased when there became a prospect of war with the British, and there were British subjects found disgraceful enough to sell arms and ammunition to the natives while the war was going on.†

On May 3,‡ the forces disembarked at *Onewero*, up the *Kiri-kiri* river (see map No. 2), having been delayed for want of information about the country, and of the

* B. B. 1845, 46. † Col. Despard, U. S. Mag. 1846.
‡ Col. Hulme's dispatch, B. B.

5. OKAIHU. 1845.

position of *Heki*. It was ascertained from the natives that he had established himself in a pah at *Okaihu*, a place about eighteen miles inland. They were entirely dependent on the natives for information and guidance to this place.

The force consisted of part of the 58th, 96th, and seamen and marines, of the "North Star" and "Hazard," altogether about 400 men, under Lieutenant-Colonel Hulme, 96th. *Tomati-waka* joined with about 400 natives.* With this force, and without transport, without a gun, Colonel Hulme undertook to penetrate eighteen miles in a country almost unknown, but which had been already reported impracticable for troops,† to attack a pah, such as had been pronounced by several authorities before to be proof against field artillery.

Having no means of transport, the men carried thirty extra rounds of ammunition and five days' biscuit, and in heavy rain, without tents, they marched eighteen miles in two days, by a narrow path through a thick forest. Two-thirds of the ammunition, and all the biscuit, was found unfit for use.‡

The pah was built expressly for this occasion; it had three rows of palisades and a ditch inside, the exterior row being coated with the leaves of the flax plant, to conceal the effect of musket-balls upon it.

May 8, three storming parties advanced within 200 yards of the pah, and some rockets were fired at it (they were brought from H.M.S. "Hazard," and were probably 3-pounders); but they had no effect. Rockets would, however, be very useful to fire into a pah—they would destroy the houses.

At the same time, the natives made a sally from the pah, and with another party, under *Kawiti*, which had been concealed in the neighbouring forest, had some skirmishing with the troops; the natives had to retreat again, without much loss on either side.§

Colonel Hulme now finding that his expedition was in vain without artillery, marched back his force on the 10th the same way they came. They were not molested on their retreat, neither had they been on the advance; and they had still greater difficulties about transport, owing to the wounded. They had been ten days on shore, and the medical officers said that any further such exposure, without cover or rations, would produce sickness.

Killed on this occasion.

| Naval. | Military. |
|---|---|
| 2 men. | 12 men.‖ |

REMARKS.

As this was the first regular expedition with troops against the natives, and as all the subsequent expeditions were much of the same character, this seems a proper place for making some remarks upon them.

1st.—*I think the mistake at Okaihu was in attempting such an expedition at all, with such means,—chiefly* because of the character of the country, which was known at the time to be such as has been described; necessitating a long, straggling, slow line of march; preventing the carriage of guns, ammunition, or provisions, except by making cart roads; permitting the baggage and the whole force to be cut off piecemeal by the natives in the forests; utterly impracticable for the evolutions of disciplined troops; indeed, that very country had been reported, in 1844, as impracticable for troops: ¶—

* "New Zealander" paper.
† Lieut. Bennett, Capt. F. pamphlet.
‡ Col. Hulme's dispatches. Local papers.
§ U. S. Mag., Dec. 1847.
‖ Ibid.
¶ Lieut. Bennett, Capt. F.

*Secondly*, because of the character of the natives and their pahs, which was also known at the time to be such as has been described; the natives accustomed to the attack and defence of pahs, and well armed with muskets; the pahs proof against field artillery, and situated in the most difficult positions. 5. OKAIHU. 1845.

I think the attack of such a stockade, eighteen miles inland, under such circumstances, was most unlikely to succeed; and we now know, from subsequent experience, that it could not have succeeded—that the pahs were all but proof against the heaviest field artillery—and, indeed, that it is chiefly owing to the unwarlike character of the New Zealander that any of our troops have returned from their expeditions alive.

2ndly.—I think it would have been better to have established a strong military post at *Kororarika*, and to have waited until further information concerning the country was obtained, and until an equipment and a force suitable to such a service was provided. The description of force necessary to have reduced one of these pahs (judging from the experience of the subsequent expeditions) would have been about 500 infantry, four howitzers (two 12-pounders and two 24-pounders), with some rockets, and some sappers to make the road and batteries. Such an equipment would have required perhaps ten bullocks (including ammunition and provisions), as the howitzers might be drawn on their field-carriages by hand, and the ammunition and provisions on the backs of the animals; this force might have moved at the rate of four or five miles a day through that open country. A breach should be made by such guns in two days, and the whole result of any of the expeditions would be obtained in a much shorter time.

Or, the guns might have been dispensed with altogether, and the 500 men might have advanced with the bullocks alone in one day, and blown the pah in with bags of gunpowder. Four or five bags of 50 lb. each would make a practicable breach in any of the pahs we have had to deal with. Of course, the great question is the placing of the bags; but, from my experience of the natives, I believe that so little watch is kept by them during the night, that the bags might be laid without discovery just before daylight. It would be a dangerous undertaking, no doubt (but not more so than the assault of *Ohaiawai*), and its practicability would depend on situation and circumstances.*

3rdly.—But even under any circumstances, with either of these equipments, and the best troops and guns in the world, I doubt if they would have succeeded in producing a much better impression on the natives. The advance even of the best equipped regular force would necessarily be slow. The want of information, of transport, ammunition, medicines, tents, would prevent them advancing above a few miles a day in such country; they would still be liable to be cut off on the march; for although the general character of native fighting is to remain in their pahs for the attack, yet they do practise ambuscades when they see a favourable opportunity. And after all, when the troops had arrived at the pah, they could not "invest" it, so as to prevent the enemy's communicating or sallying out into the forest; and, finally, when they had made their breach, on the point of the assault the enemy would evacuate, and retreat ten miles further to another pah; leaving the troops to follow by another slow march, and make another breach, only to find the pah again evacuated. For the loss of a fighting pah is a small shame to the *Maori;* it would be probably built only for the fight, and perhaps on another man's land, and it does not take them long to build—*Waka* built a small one for the troops

* See report of experiments at Chatham at conclusion of Part III.

6. OKAIHU. 1845.

in one day. It is only when the people are captured in the pah that a lasting effect is made; the *Maori* counts the numbers slain or made prisoners, in reckoning up *his* wars.

4thly.—On the other hand, the colonists and native allies were urging on the commander to put an end to the disturbed state of the country; and it was not thought that the natives would stand to meet such a force of troops, even behind a pah, and the pahs themselves were not well known (Lieutenant Bennett's description had been buried in the archives of some office, instead of being published to the officers); in short, the enemy was undervalued, and finally, there was no such equipment in the colony as I have mentioned. However, on the whole, I think it would have saved the subsequent campaigns to have waited in a post at *Kororarika* until the proper equipment was ready.

5thly.—It is very satisfactory to find that, with all these difficulties to encounter, the troops themselves behaved exceedingly well. They surmounted the difficulties of the country steadily, and after going through them all they showed, when they had the opportunity in the sally and ambush, that they could drive back the natives hand to hand on equal terms. These are circumstances when the drill and whole education of the soldier is at fault; the discipline and manœuvring of the parade are almost useless; each man is thrown on his individual resources; nevertheless, notwithstanding the totally new circumstances in which they were placed, I do not think there is any case recorded in the whole wars in which, with anything like a fair field, they did not easily drive back the natives.

6thly.—The native allies require some notice here. We have always had native allies in our wars in New Zealand. They have generally acted as guides and followers; from their custom of having frequent communication with the enemy, the commanders found out where the enemy was, and the path to him, of which, otherwise, they would have been totally in the dark; they assisted (on being paid) in the carriage of stores; and made huts for the troops. The commanders have accused them of being lukewarm, but they showed good fight on some occasions, and were, on the whole, faithful after their manner.

It is not to be expected that they would put themselves much in the front in a foreign cause; it was a very great point gained that they did not oppose it; and it is not, I should think, a desirable thing that one tribe of natives should be allowed to fight another tribe for the defence of British interests; however this practice may have succeeded in other countries, in New Zealand it would only tend to breed suspicion, and sow such internal discord between tribes as would cost more to allay than the war which gave occasion for it. They should only be called upon to assist the forces; except as in the case of *Kororarika*, when a chief offered to come with 300 men to the defence against *Heki*, which was refused, unnecessarily, I think.

6. OHAIAWAI.

## SECT. VI.—OHAIAWAI.

Just before *Okaihu* Colonel Hulme took the chief *Pomare* prisoner; *Pomare* had come, under a flag of truce, into the camp of the British force, and the colonel kept him, as he was justly suspected. He might easily have been captured by force, and, after all, he was only detained a few weeks. You cannot fight savages exactly on the same terms as civilised forces, but still, the more openly the war is conducted, the more the *Maori* will respect the civilisation.*

* Dispatches in local papers and B. B. 1846.

6. OHAIAWAI. 1845.

It was unnecessary to destroy his pah; but there is no doubt Colonel Hulme was actuated by feelings of humanity. The character for gallantry he obtained, even during this short campaign, is a sufficient proof of that.*

May 15th, Major Bridge, 58th, with 200 men, took the pah of *Waikari* by night; the natives evacuated the pah with hardly any resistance; it was only an ordinary pah of no great strength.†

The troops on arriving at the *Kawa Kawa* re-embarked, and *returned to Auckland!* It does not appear why the force was thus withdrawn, why they did not occupy *Kororarika*, or some good military post there, as a basis of future operations; no doubt it was under orders from the Governor; but this apparent retreat from the country (for the third time) must have given great encouragement to *Heki*, and as much discouragement to our allies. Accordingly, we find that, on May 31, *Heki* wrote such a letter to the Governor as showed that he felt very confident in his own strength, and elated with the general success of his former operations.‡

However, the Governor was now thoroughly aroused, and further reinforcements (which he had continued to ask for) arriving from Sydney, he ordered the fourth expedition against *Heki* to be undertaken immediately.

June 1st, 200 men, 99th, arrived from Sydney, under Lieutenant-Colonel Despard, who took command of all the forces in New Zealand, as colonel on the staff. They immediately proceeded on to the Bay of Islands, with other troops and some volunteers from Auckland, and four field pieces, which were placed under the command of Lieutenant Wilmot, R.A., lately arrived as a volunteer from Van Diemen's Land.§

It appears that *Heki*, notwithstanding his boasting, must have been afraid to risk another siege in *Okaihu*, for, after some skirmishing with the friendly natives, he retreated to a still stronger pah he had built on purpose at *Ohaiawai*, near Lake *Omapere*.

Colonel Despard resolved to attack him there; and here we have over again the same description of campaign as before. This expedition was certainly rather better equipped; the style of equipment had advanced from the fifty men at *Kororarika* on to the 400 and two rockets at *Okaihu*, and now reached to 600, and four field pieces for *Ohaiawai;* but there were the same delays for want of information and transport, and the same toilsome march through thick forests; the field pieces were such as Lieutenant Bennett, two years before, had pronounced useless against ordinary pahs, and this was known to be one of extraordinary strength. The evils arising from these wants, and bad organisation, are not all chargeable to the commanding officer: he was obliged to work with such equipments and troops as he found in the colony; the fault he can be charged with, is having undertaken such an expedition at all with such means.

We have the description of the failure of these means from the commanding officer himself.

On the 14th of June the whole force proceeded to the *Kiri Kiri* river in H.M.S. "Hazard," and the other vessels; one of these got on shore in going up the Bay of Islands; but there was nothing peculiar to the place or to the circumstances in this accident; it might have happened anywhere; however, it delayed the advance two days; and on the 16th of June they landed at *Onewero*, at the

* Dispatches in local papers and B. B. 1846. † Ibid.
‡ B. B. 1846. § N. Zr. paper, Nov. 1845, and U. S. Mag. 1846.

6. OHAIAWAI. 1845.

mouth of the *Kiri Kiri* river (see page 55 for description), and marched to *Kiri Kiri* missionary station. The following is an extract from Lieutenant-Colonel Despard's account of the campaign in the United Service Magazine, August, 1846:—

"Having reached our destination about twelve o'clock the same day (16th), and everything having been previously prepared for disembarking, no time was lost in commencing it; but as there was a considerable distance to go in boats before a proper place could be found for landing at, owing to the hilly and woody nature of the banks, they were not all on shore till four in the afternoon. The road to *Kiri* was a bad and difficult one, with numerous valleys, and each having a swamp or boggy stream at the bottom, which rendered our march slow and tedious.

"At three o'clock the following morning, the boats with the guns, ammunition, and camp equipage, reached *Kiri Kiri* missionary station (the river being navigable for boats so far), under the superintendence of that indefatigable officer, Acting-Commander Johnston, of H.M.S. "Hazard." All these being landed, our next operation was to muster our drays and carts, and to ascertain what was the amount of transport carriage within our reach. Three drays were all that could be procured, and two carts with two horses each, which had accompanied us from Auckland. This obliged me to *leave half the ammunition behind;* no private baggage for officers or men could be taken, and the *greatest part of our provisions* was obliged to be placed in store at *Kiri*, and there wait for favourable opportunities of having them sent after us.

"The officers hired natives to carry their baggage, each officer having only a knapsack, havresack, and blanket.

"One of my greatest difficulties was the carriage of the four guns," which was effected—"by attaching them to the tail of a bullock dray. Scarcely a rivulet was passed that some of the guns did not upset, and were sometimes lost sight of in mud and water. The troops left *Kiri Kiri* at one P.M.: in crossing the second rivulet, the bottom being unsound, the shaft of a horse cart broke, and as there was no possibility of repairing it, I was obliged to leave a captain and fifty men to protect it, as it was *loaded with ammunition.*

"Two miles further on two more of our carriages broke down; it was then quite dark and raining in torrents; I made a general halt till the moon rose, and then about midnight passed through the wood; 100 men remained to protect the drays—we arrived at *Waimate* at half past two A.M., twelve miles in thirteen hours! The fifty men with the first broken-down cart arrived at two P.M., having unloaded the cart and brought the things by hand."

I consider this a fair specimen of the difficulties that have attended almost all movements of troops in New Zealand, and I think it shows the extreme difficulty of making successful campaigns against the natives in the interior with regular troops; for even supposing the commanding officer to have provided himself beforehand with means of transport (which he ought to have done), and to have been properly equipped with guns and engineering implements from England (as he should have been), there would still have been great delay in traversing the country—and such a country, where the hostile natives might have cut them off one by one; it is true the natives did not molest them, but kept to their stronghold twenty miles inland, but they seemed to be aware of their opportunity of doing so, as they boasted (Colonel Despard says) of their forbearance in not destroying the missionary establishment at *Waimate*, which served as a depot for the military operations, and also a bridge on the road to it.

6. OHAIAWAI. June, 1845.

The force* then at *Waimate* consisted of—

Lieut.-Col. Despard, 99th, commanding.

| | | | |
|---|---|---|---|
| 58th regiment, Major Bridge | | 270 | |
| 96th „ Lieut.-Col. Hulme | | 70 | |
| 99th „ Br.-Major Macpherson | | 180 | |
| Lieut. Wilmot, R. Art. | 4 guns | | 2 6-pr. brass<br>2 12-pr. carronades |
| Capt. Marlow, R.E. | | | |
| H.M.S. "Hazard," Capt. Johnston, R.N. | | 30 | |
| Volunteers, Lieut. Figg | | 80 | |
| | | 630 | |
| Native allies under *Tomatiwaka* | | 250 | |

The enemy in the pah was supposed to have been about 250.

The force waited at *Waimate* till the 23rd of June for supplies from the *Keri Keri*. Several chiefs visited Colonel Despard, and gave their support to the expedition; among these were *Tomati-waka, Macquarie, Moses Tawai, Patuona, Repa*, and *Pomare*.† On the 23rd of June the force marched from *Waimate* to *Ohaiawai*. The distance was only seven miles, but the country being of the same impracticable nature as before, it occupied them the whole day.

The pah was situated in a clear level space in the forest, about 500 yards square, having on each side of it a ravine with wooded hills; all the rest of the country was thickly wooded: it had three rows of palisades, the two outer rows being close together, and six feet from the inner row which was made of trunks of trees 9 in. to 20 in. diameter, and 15 ft. high. Between the rows was a ditch 5 ft. deep with traverses, from which the defenders fired through loopholes on a level with the ground; the ditch communicated with the interior by passages under the inner palisade. There was a coating of flax leaves 6 in. thick on the outer palisades. The huts inside had excavations under them for protection against shot; but the natives are accustomed to make these for keeping potatoes in. The pah was about ninety yards by fifty, and had a square flank projecting on each side.‡

There was a small range of hills on the right which was immediately occupied by the native allies; the troops encamped among the potatoe gardens of the pah in a small hollow within 400 yards of it, but out of view. On the night of the 23rd, a battery for the four guns was made 100 yards in front of the camp; it fired all day on the 24th *without effect*, which was partly owing to the inefficiency of the carriages and inconvenience of the batteries, which was on very rough ground, and covered by a breast-work of timber coated with flax leaves: but 12-pr. carronades and 6-pr. guns would not produce much effect on such a stockade even with the best carriages and platforms.§ They were tried again in another battery at 250 yards, and again at 80 yards from the pah, and as they produced no better effect even at the latter distance, and as the natives kept up a sharp fire upon them from the pah, *these guns were finally withdrawn.* And this force would probably have been obliged to follow the example of *Okaihu* if Commander Johnston had not brought up a 32-pr. from the "Hazard," which was effected by the help of a dray and a double team of bullocks in one day. During the day and night of the 30th a battery was made for it at the foot of *Waka's*

* Lieut. Balneavis, 58th.
† Col. Despard, U. S. Mag., Aug. 1846.
‡ Capt. Marlow's dispatch and plan.
§ Col. Despard, U. S. Mag., Aug. 1846.

6. OHAIAWAI. July, 1845.

hill, about 100 yards from the pah, to fire *obliquely* on the palisades. It fired 26 shot on the 1st, which, in Colonel Despard's opinion, so loosened the palisading, that he ordered it to be assaulted. Captain Marlow, R.E., did not think the breach practicable, and it proved not to be so.*

About ten A.M. on the same day the natives made a sortie from the pah upon *Waka's* position, taking advantage of there being only a few men on guard there; our native allies had half finished a stockade for themselves on this hill; the enemy came so suddenly upon them that the senior officers of the British force, who happened to be there, were nearly captured. The look-out could not have been very good, but two or three sentries in red coats are not a match for the movements of dusky savages, in broken wooden country. After the first surprise the enemy were soon driven back into the pah.

The assault was made at three P.M. by 160 men divided into two parties under Brevet-major Macpherson, and Major Bridge, and followed by forty seamen and pioneers, under Lieut. Phillpotts, R.N., with hatchets, ropes, and ladders. They got within eighty yards under cover of a gully, below *Waka's* hill, and then rushed at the pah. For ten minutes they tried manfully to force a way through the almost unbroken palisades with nothing but their swords and bayonets, for they had unfortunately thrown away the hatchets and ropes which might have been of some use, and they actually got through the first palisade, and the natives inside ceased firing in fear, until they found that the inner palisade still resisted every effort, and then the assaulting party, having lost two officers and half their force in killed and wounded, were compelled to fall back.

From the 1st to the 9th July, little or nothing was done, there being no gun-ammunition in camp; and Colonel Despard entertained some idea of retreating, for he says, "The boldness of this attack (the sally) convinced me that he was gaining confidence by the little effect which our guns had hitherto had upon him; and I considered there would be every chance of his sending out a party secretly at night and cutting off all our supplies, which were brought up from the rear every two or three days, and, by destroying the few drays I had and carrying off the cattle, have forced me to retreat, and leave everything behind."

But on the 9th, some ammunition arrived for the 32-pounder, and it re-commenced, but fired only into the pah, the idea of a breach being given up. The natives, however, would not risk another assault; on the night of the 10th they evacuated the pah, retreating to a still stronger position at *Ikorangi*, about ten miles further. The pah was then destroyed.

Killed in this campaign.

| Naval. | Military. |
|---|---|
| Lieut. Phillpotts, R.N. H.M.S. "Hazard." | Capt. Grant, 58th |
| | Ens. Beatty (died of wounds). |

36 men.

REMARKS.

Here is a repetition of the *Okaihu* campaign, with a rather better equipment, and a rather better result: the same remarks apply, and in some particular parts rather more strongly, every step of the campaign showing the inefficiency of the means.

* Col. D., U. S. Mag. 1846, and U. S. Mag. 1847.

1st.—We have a want of bullocks at landing, though these might have been provided by the commander beforehand. 6. Cheteawai. July, 1845.

2ndly.—We have guns on garrison-carriages that won't travel, and drays breaking down. The guns should have been on travelling-carriages, and the ammunition and stores packed on the backs of the bullocks. This, however, was not the fault of the commander. Here we see the want of a force of Sappers to form the road, repair the carriages, and construct packs for the bullocks.

3rdly.—The guns are found useless when they arrive and are placed in position. This might have been known before, from Lieut. Bennett's report. The 32-pounder was as much too large as the others were too small; for the weight of the ammunition prevented a sufficient supply being brought up in time. The want of artificer Sappers is shown again in the construction of the batteries.

4thly.—The commander undertakes a regular siege, and is apprehensive lest the besieged should cut off his retreat: can there be a stronger evidence of the difficulty of succeeding with regular troops against savages? But no commander could depend on his communications under such circumstances. It is only owing to the native allies and the character of native fighting, that we now have Colonel Despard's testimony on the subject.

5thly.—The lives of some brave men were expended upon a useless assault—that is to say, the strength of the stockade was undervalued, and the effect of the shot over-estimated; it took twenty men to pull down some of the posts after it was taken.

6thly.—Finally, the enemy escapes with the loss only of his pah, and sufficiently elated by the number killed to produce another campaign.

7thly.—Thus it appears that the increased equipment entailed a still slower march. Instead of a week, they were a month on the campaign: eight days going fifteen miles, and sixteen days besieging the pah; all rendering them still more liable to be cut off on the march. The troops were better fed; but they had to go through greater fatigues, and make a more desperate attack; and, after all, the enemy was but slightly punished. Now, as I observed before, the fault of this inefficient equipment is not entirely to be laid to the commander; there were no proper guns in the colony, nor Artillerymen, nor Sappers. But what I do argue from this campaign is, that it would have been better if Colonel Hulme, and after him, Colonel Despard, had been content with occupying a position at *Kororarika*, and waited until the proper force and equipment could be provided, instead of advancing one time after another with a mere display of force, which produced no permanent impression on the natives.

8thly.—And further, I argue from it, that also in this case, as at *Okaihu*, even if the equipment and force then proposed had been forthcoming, it would not have "invested" the enemy in his pah, or prevented his final escape from it; but that to capture such an enemy in such a position requires a force specially equipped and organised for the purpose.

9thly.—Here, again, we find evidence of the good behaviour of the troops under the inefficiency of equipment. Those only who have travelled in the bush in New Zealand in rainy weather can judge of the difficulties a body of troops must have to encounter. If the settler finds it labour enough merely to traverse such country in time of peace, surely troops, ignorant of the road, totally unprepared, and unaccustomed to such work, deserve some credit for going through it all so cheerfully, and, after it all, beating back the sallies and attacking so energetically a half-breached pah of such strength. Colonel Despard bears witness to the

6.
OHAIAWAI.

gallantry of the assault (especially mentioning Ensign Beatty, of the 58th); and also to the patience of the wounded lying in tents in the midst of rain, mud, firing, and noise. Surely it proves not only that the fault of the ill-success is not to be laid to the men themselves, but even that these very men, properly equipped and trained, would be a match for any *Maories* in any part of New Zealand.

10thly.—Colonel Despard does not speak highly of the assistance he received from the native allies under *Tomati-waka.** They acted as guides, and gave information and advice about the country, and carried things on the march (for which they took care to get well paid): but they acted entirely in accordance with their own tactics: long talking, exciting preparations, sudden spurts, daring skirmishes for a little, and then talk again for a week. They desired to be friendly to the British: it was not to be expected that they should take a prominent part in a quarrel they had not much personal concern in—and for strangers against their countrymen. Colonel Despard's recommendation, "to be able to act independently of the natives," is worthy to be remembered by all officers.

When he proposed to retreat (before the 9th) they opposed it with great excitement; for they would have been left to bear the whole force of a campaign from the victorious *Heki.*

There was a great quantity of provisions found in the pah;—this is the first point the natives look to in commencing a campaign, and a first cause for their retreating or making peace.

There were also four guns found in the pah, but the natives never used them; in fact, they could not.

July 14th.—The whole force returned to *Waimati.* Colonel Despard now prepared to follow up his success with spirit: he sent 200 men with two guns to attack *Aratoa's* pah about five miles from *Waimate*; but *Aratoa* had learnt a lesson from *Ohaiawai,* and he evacuated the pah as they approached. It was as well Colonel Despard was not obliged to try another siege, for there was a difficult stream on the road, with a broken bridge, which would have led to the usual delays for guns, &c., and the site of the pah was a very strong one. The difficulties in cutting paths through the forest, making rough bridges, batteries, stockades, &c., show the very great want of a company of Sappers and Miners in these expeditions.

But Governor Fitzroy put a stop to these energetic proceedings: willing to give *Heki* every chance of repenting, he ordered Colonel Despard to Auckland on some minor duty, and prohibited further offensive operations until further orders. *Heki* and *Kawiti* employed the time in negotiating with the Governor for pardon, and building new pahs for defence, which led to the fifth and last campaign against them.

There was a good deal said during this last affair about the interference of the missionaries. I fully believe that these gentlemen, deceived and misguided as they were in their estimate of the natives, had throughout the most conscientious desire to maintain peace, and most honourable feelings towards their own Government. Several of their body were held in high esteem, and rendered good service to their country; but they went to the extreme of blaming the troops for fighting on Sunday, as if it was more humane to kill twice as many men by protracting the war.

* U.S. Mag. 1846.

7. RUAPEKAPEKA. 1846.

## SECTION VII.—RUAPEKAPEKA.

After *Ohaiawai*, the greatest part of the force remained in camp at *Waimate*, and employed themselves during four months of inactivity in forming an intrenched camp there. Colonel Despard put a stop to it when he returned. It is very possible that the intrenchments may have been much too large, as he says; nevertheless, it is a very desirable and necessary thing for troops to intrench or fortify themselves wherever they are encamped in New Zealand, in order that a small body may protect the magazines, leaving a large force available for attack, to be secure against surprise, and it would have prevented the effect of alarms.

Colonel Despard employed the time at Auckland in endeavouring to provide a little better equipment; some field gun-carriages were made; but he could only succeed in producing a force similar to what had been used before; there were better guns and drays, &c., but all of the same character, necessitating slow advance and cautious measures. He, however, received more men from Sydney, the result of the Governor's continued applications, and two more ships of war, as noted below. He returned to the Bay and *Waimate* August 27th. The Governor still endeavoured to bring the enemy to reason, and the letters from *Heki* and *Kawiti*, between *Ohaiawai* and *Ruapekapeka*, show them to have been only half confident in their former escapes and powers.* *Heki* had even separated from *Kawiti*, and seemed inclined to wait the issue of *Kawiti's* pah, which he was constructing at *Ruapekapeka*. The fact is, that no savages (and especially no *Maories*) can carry on a campaign for any length of time together; their physical strength becomes exhausted, and their spirit wears out; they like, according to their own system, to have a little fight and then a little peace, and then at a convenient season to commence fighting again. And at that season of the year they began to be short of potatoes, which has a great effect upon a *Maori*, although he is accustomed to feed on fern root in his native wars. Hence *Heki's* followers began to desire peace, at the same time collecting food and building pahs for the future; but *Heki* himself was too conceited and had too deep a dislike to British rule to give in, and *Kawiti's* pride and ancient feuds against our native allies was roused; and they were both afraid of losing their land, for Governor Fitzroy had made the surrender of land one of the articles of peace, a condition which alone would have ever prevented a satisfactory issue. The natives themselves seemed perfectly aware of these points in their own character; for at a *korero*, or public meeting, held on the arrival of *Nopera*, a chief of the north, who joined the allies with 100 men in September, they gave very sound reasons for vigorous war, founded on *Heki's* character; and *Kawiti*, in a letter to the Governor, accuses *Waka* of fighting on account of old feuds; he was always "naming his dead of old times," and was "not fighting for our (the British) dead." This intelligence and quickness of argument which the *Maori* possesses beyond most savages, inclines strangers to place too much confidence in them, but I think the sight of the sagacious *Waka*, stamping the war dance in full post-captain's uniform, ought to make one cautious in relying upon so excitable a character.†

It is evident that savages of this character are not to be subdued by occasional shows of troops, long desultory campaigns, with long intervals of inactivity and negotiation; these are too much in their own style—they like such campaigns.

* B. B. 1846, and U. S. Mag. 1846.

† U. S. Mag. 1846.

7. RUAPEKAPEKA. — 1846.

They should be tired out with incessant harassing surprises for weeks together, without a day at leisure; but Governor Fitzroy wished to spare bloodshed, so he ordered the troops from *Waimate* to *Kororarika* (against Colonel Despard's opinion), and commenced a strong military post at the latter place. Probably the Governor would have considered the establishment of this post a sufficient guarantee for future peace; but at this point he was recalled by the Home Government, and Captain Grey appointed in his place.

*In August, H.M.S. "North Star," "Osprey," and "Racehorse," arrived at the Bay, the "Hazard" having been relieved; and a detachment of the 58th arrived about the same time. On the 4th of October, the head quarters 58th, under Lieutenant-Colonel Wynyard, arrived in the transport "British Sovereign," and anchored in the *Kiri Kiri* river. She also brought six 24-pounders, of 50 cwt., which Colonel Despard properly describes as useless; and 4 brass mortars 4½ in., weighing 1 cwt. each, which were found useful.

Nov. 4.—A detachment of the 99th arrived from Sydney, bringing three more mortars and thirteen bullocks; these latter were the most useful part of a field equipment that could have been sent, and unfortunately eleven more had died on the passage; and their loss added at least a week to the campaign. Just as this (comparatively) large and well-equipped force assembled, Captain Grey arrived (Nov. 21) at the Bay from Auckland, in the East India Company's ship of war "Elphinstone."

Captain Grey was appointed at a most fortunate time for the success of the principles he had laid down for the government of savages in South Australia. The sum of these principles were,† that all natives should be placed under the control of British law, and not allowed to practise their own customs. Such principles could not be put in practice in New Zealand, without a considerable force in men and money, and Captain Fitzroy had neither of these; the absence of troops was his own fault in delaying so long to ask for them; but money was always denied him by the Home Government: ‡ they did not sufficiently consider the absolute necessity of supplying a young colony very largely with funds to start with. But now the continued difficulties, and Captain Fitzroy's now constant demands, had brought Lord Stanley (then Colonial Secretary) to acknowledge the necessity of supplying both; and when Governor Grey took the command the tide had completely turned in favour of New Zealand. He had 500 men, 4 ships of war, and 20,000*l.* His first act on landing was to stop the forts building at *Kororarika;* he might, however, as well have allowed something to be done, as the troops are to this day without any defences at that station. He then gave *Heki* and *Kawiti* a fixed time to decide upon peace or war, which infused confidence into the native allies; he perhaps carried the negotiations a little too far, for he finally got such answers as made him give Colonel Despard the orders to attack *Ruapekapeka* forthwith.

Then commenced the usual slow advance of the regular forces; and here again we have the history of the delays from the commander himself.

The following troops were engaged at Ruapekapeka:—

* Lieut. Balneavis, 58th, and U. S. Mag. 1846, and B. B. 1846.

† Nelson petition, 1845.

‡ Capt. Fitzroy's pamphlet and B. B. 1846.

7. RUAPEKA-PEKA. 1846.

Lieut.-Col. Despard, 99th, commanding.

NAVAL.

| | | Officers. | Men. |
|---|---|---|---|
| Seamen, H.M.S. "Castor," "N. Star," "Racehorse," H.E.I.C. "Elphinstone" | Commander Hay, R.N. | 33 | 280* |

MILITARY.

| | | | |
|---|---|---|---|
| Royal Artillery, Royal Engineers . . | Lieut. Wilmot, R.A. . / Capt. Marlow, R.E. . . | 2 | 0 |
| Royal Marines . . . . . . | Capt. Langford . . | 4 | 80 |
| 58th . . . . . . . . . | Lieut.-Col. Wynyard . | 20 | 543 |
| 99th . . . . . . . . | Capt. Reed . . . | 7 | 150 |
| H.E.I.C. Artillery . . . . . | Lieut. Leeds . . . | 1 | 15 |
| Volunteers from Auckland . . | Capt. Atkyns . . | 1 | 42 |
| | Total . . | 68 | 1110 |
| Native allies under *Tomati-waka, Nopera, Repa, Moses*, &c. . | | | 450 |

Mr. Turner was the D. A. Commissary General.

ORDNANCE.

| | | |
|---|---|---|
| 3 32-prs. | 2 12-pr. howrs. | 4 4½ mortars |
| 1 18-pr. | 1 6-pr brass gun | 2 rocket-tubes. |

The enemy in the pah supposed to be 500.

Dec. 8, 9.—These two days were occupied in moving the force in the men-of-war and transports up the *Kawa Kawa*, as far as the junction of the *Waikari*, where they encamped (see Map, No. 2).

Dec. 10, 11.—These two days were occupied in moving the force on up the *Kawa Kawa* to *Pukututu's* pah. This was intended to have been done by the river in boats, but at the last moment it was found that the boats would not hold the force, so part of them marched by a native path on the left bank, which was shown them by a native. The country about this river appears to have been open, consisting of long ranges of hills a few hundred feet high, covered with thick fern and *Manuka* (the tea-tree of Australia, which when young is like very tall heather); and with flat swampy valleys in between, through which the stream wound, and only timbered in ravines.

Dec. 12—Was employed in bringing up the heavy guns by water, and collecting bullocks; and even now, at the last moment, after five months' preparation, these indispensable necessaries for the movement of troops were not provided. "In this branch of our armament we were very defective; when all the bullocks which could be collected were brought into the camp, there were only sufficient for six drays, and there was also one 3-horse cart."† Sixty men, soldiers and sailors, under Commander Johnston and Lieutenant Holmes, R.N., were left to protect this situation at *Pukututu's* pah, as it formed a depot.

Dec. 13 to 22—Were occupied in reconnoitering the country, and making a practicable path towards *Ruapekapeka*. This very slow cautious progress is very certain, and was then unavoidable, but it presupposes that your enemy will wait patiently in his pah for a month or so until you get up to him; and that the destruction of his pah is all you desire. The enemy did fortunately remain in

* H.M.S. "Castor" arrived on the 15th, and 100 men from her joined the force on the 20th.
† U. S. Mag. 1846.

7. RUAPEKA-PEKA. 1846.

his pah, but he escaped from it at the last moment, and the loss of it was of little consequence. To have inflicted a real blow upon him, the commander should have prepared his bullocks and reconnoitered his road, and made his path beforehand; or elsewhere provided such a force that he could have advanced at once without any of these preparations. As it was, the slow progress was unavoidable: "we crossed a small river, and thence the troops were obliged to move in single file, the path being very narrow, and on both sides covered thickly with fern, 2 or 3 feet in height, mixed with tea-tree 6 or 7 feet high." * The country was a constant succession of hills. Then, on reconnoitering another line, "we came to a ravine, not less than 150 yards across and 60 feet deep; the descent became perpendicular at bottom; the opposite bank thickly wooded with timber." And such hills and such ravines are rather easy travelling for New Zealand. Regular troops, which are taught only to move as a body, and depend on the voice of one commander for every slightest move, are not fitted for such a country where every soldier ought to be independent in himself. One hundred men, chiefly the volunteers, were employed making the path practicable for drays for the first seven miles; and on the 22nd, the force advanced this distance, and encamped and halted for three days to bring up the rest of the stores, &c.

At this camp "the path from *Heki's* supposed present place of residence joined that to *Kawiti's* pah," therefore, "by our occupation of the position, his approach by that route was completely cut off"*—but it is impossible to cut off the march of natives by merely occupying their usual paths; in war time, as each native carries his clothing, arms, and ammunition, and the women carry the food, and they have no shoes to wet, and can hut themselves anywhere, they are independent of all paths.

Dec. 27.—The force moved on again five miles in a *few* hours, to within a mile of ***Ruapekapeka***.† The pah was situated on the narrow ridge along which they had been advancing all the way from the *Kawa Kawa*, and which about here began to be thickly wooded, especially in the steep ravines on each side. The actual site of the pah was cleared of trees, and sloped towards the British camp, and the ridge took a bend between the pah and the camp, so that from the camp, which was on a high knoll, there was a good view of the pah across the intervening ravine. The native allies now went to the front and had some skirmishing with the enemy, and built themselves a pah at about 1200 yards from the enemy's: and on the 29th, they advanced to within 800 yards of the pah in an open space in the wood, and a detachment of troops followed and occupied this position, and the camp of attack was made here; where there was forest, of course a way for the drays had to be cut through; indeed, the difficulties of the transport were such, that notwithstanding his large force, Colonel Despard was glad of the arrival of a further detachment of 100 of the 58th (included in the return above), "as our men were beginning to be a good deal harassed from the difficulties of the road (*i. e.* the way cut by the pioneers), which, being much cut up by the late rainy weather, it frequently required sixty men, in addition to a team of eight bullocks to each gun, to get it up the hills and through the woods, besides being afterwards obliged to stop till some large tree was cut down, perhaps 6 feet in diameter." They had even to cut lines of fire through the wood for the guns.

No wonder it was the 31st December before the whole force were in camp, and the 9th January before all the guns and ammunition arrived: between the 1st and

* U. S. Mag. 1846. † Lieut. Balneavis, 58th.

9th three batteries were made : first, in front of the camp, at about 650 yards,* or one 32-pounder and one 12-pounder howitzer; second, at 300 yards from the pah, of two 32-pounders and the 4½ inch mortars; third, at 150 yards, of one 18-pounder and one 12-pounder howitzer; all bearing upon the same face (the west face) of the pah. The batteries were covered by stockades of rough timber.

7. RUAPEKA-PEKA. 1846.

During this time some trial shots were made from the 650 yards with guns and 24-pounder rockets; the latter rather failed; they must have been bad rockets, as Colonel Despard supposes, otherwise these weapons are most useful in such service—for firing *into* pahs; and from their portability, a great many can be carried with a body of troops without delaying them.

This pah was about 120 yards by 70 (see Plan), and much broken into flanks; it had two rows of palisades 3 feet apart composed of timber 12 inches to 20 inches diameter, and 15 feet out of the ground. Inside these two rows was a ditch 4 feet deep, with earthen traverses left in it, and the earth was thrown up behind to form an inner parapet : each hut inside was also surrounded by a strong low palisade, and the ground excavated inside the hut, and the earth thrown up as a parapet; in fact, similar to *Ohaiawai*, except that the interior stockading and excavations were more extensive, though these would not afford much defence after troops were once inside.*

On the 2nd January the natives made a sally from the pah, and were beaten back with great spirit by the native allies alone; they had requested that the troops might not interfere, having found out, I suppose, that the soldiers could not well distinguish between friend and foe. These native skirmishes consist in individual skirmishing behind trees, led on by the shouts and example of some chief, and this must have been a sharp one, for ten of the enemy were killed. Our ally *Repa* had been severely wounded the day before.†

The guns had commenced firing and produced some effect, on the palisade, but it would have been throwing life away to have assaulted it at that time, of which Colonel Despard appears to have had some intention.

On the 10th January all the batteries opened and fired all day, and made two small breaches in the outer stockade only; Colonel Despard says the 18-pounder at 150 yards, had nearly as much effect as the two 32-pounders at 400 yards: they kept up some firing during the night. The breach was described as difficult to get in, even without opposition; the small effect of such heavy guns must have been owing to the bad carriages and slow firing.

The enemy began to retire during the night of the 10th, taking their clothes, &c. with them, and early on the morning of the 11th, being Sunday, the natives were nearly all out behind their pah, perhaps not expecting any attack on that day; *Tomati-waka's* brother, perceiving the pah silent, crept up with some natives, and Colonel Despard finding them successful followed with a company of the 58th, under Captain Denny, and pushed through the breaches: they were received with a fire from the natives left in the pah, but reinforcements following, the troops were soon defending the pah itself against the enemy in the forest behind, and after three hours' sharp firing against the natives endeavouring to retake the pah, some of the daring sailors and soldiers having rushed out of the pah into the forest behind, the enemy retreated altogether.

Killed in this campaign.
Naval and Military.
12 men.

* Capt. Marlow, R.E., dispatch. † U. S. Mag. 1846.

7. Ruapeka-peka. 1846.

Most of these were seamen, who exposed themselves too much in the final skirmish.

The enemy were supposed to have lost about twice that number: they had nearly exhausted their provisions.

Governor Grey, Captain Graham, R.N., of the "Castor," Sir E. Home, R.N., of the "North Star," were all present during nearly the whole of this campaign.

### Remarks.

Thus, 1100 men were occupied a full month in advancing fifteen miles, and in getting possession of a pah, from which the enemy escaped at the last moment, and escaped with the satisfaction to him of a drawn battle. The question is, was it worth while to go through all that laborious march to obtain such a result? Something might have been done to strike a quicker and more effective blow even with that force; but no regular force, however well equipped, could advance fast enough to have taken the pah by surprise, and without such surprise the result would have been incomplete.

With respect to what might have been done to strike a quicker and more effective blow even with that force: I think, 1st. The bullocks for transport might have been provided beforehand; 2dly more information concerning the country might have been obtained beforehand; 3rdly, and the quantity of carriage transport required for stores, tents, provisions, and ordnance, might have been reduced. Colonel Despard did send back the tents from *Ruapekapeka*, for he found that, with the help of the natives, the troops could build for themselves huts out of the forest at each station, more comfortable than tents. Troops could hut themselves everywhere in New Zealand, except on the sandy country near the coast, and in the large plains; and provided they are instructed how to do it. The other stores might, I think, have been packed on the bullocks' backs. 4thly. The great obstacle was the ordnance; 32-pounders and 18-pounders were unnecessarily heavy to breach such a pah; the weight of them and their ammunition would be a drag that would incapacitate any expedition in New Zealand. If 24-pounder howitzers could not be obtained from the men-of-war, it would have been even better to have tried bags of powder than have taken such heavy guns a mile from the ships. The palisade of *Ruapekapeka* was not stronger than *Ohaiawai*, or than stockades that have been so breached at Chatham; and to judge by the long unmolested march of the troops, the enemy did not seem to be much on the alert.

But if this plan had been objected to, then I think it would have been better to have held the post of *Kororarika* or *Pukututu*, until a suitable equipment was provided; to have acknowledged at once that the interior was impracticable for regular troops; and to have been content with defending the neighbourhood of the stations, even until application could be made to England for a proper equipment and force. The force and equipment I think desirable have been described, but I must again observe that even that equipment would not, in my opinion, make a sufficient impression on the natives, to produce a lasting peace, unless it was assisted by a local corps specially trained for the service.

However, I am rather desirous of showing what is now still required to put the colony in a defensible state, than what might have been done; for, as before observed, there were circumstances on the other hand which forced the commander to act at once; the chief of which was the slight opinion held by everybody at the time of the strength and resources of the native enemy.

It is true that the war in the north came to an end after this last campaign. A few days after *Ruapekapeka*, both *Heki* and *Kawiti* wrote to the Governor to ask for peace in terms at last trustworthy, because they were short and decisive. And Governor Grey, on consideration of the power he now held in hand, granted it, and with it wisely unconditional pardon, without forfeiture of land; which latter article tended materially to allay future disputes between the natives themselves and jealousy of the Government. And this peace has never since been seriously disturbed, and is less likely to be so now, since the death of *Heki* and *Pomare* in 1850.

7. RUAPEKAPEKA. — 1846.

Thanks and rewards were given by Her Majesty to the troops for this last campaign. Colonel Despard, Colonel Wynyard, and Captain Graham, R.N., were made C.B.'s; Captain Marlow, R.E., Captain Denny, 58th, Lieutenant Wilmot, R.A., got brevet rank; and finally *Tomati-waka* got a pension of 100*l.* a year.

If the effect of the campaign did not seem to call for such rewards, when compared with a European battle, certainly the steadiness and cheerfulness with which the troops went through the hardships of it deserved them; for the individual labours and responsibilities were greater than in any civilised campaign, whilst the very best results that could be obtained were inappreciable by the public.

Thus ended the northern campaign. It had commenced in July, 1844, with the first cutting down of the flagstaff, and continued till January, 1846; each campaign had required an increase of force, and even at the last the equipment was inefficient, the natives undervalued. It is evident now, that a display of force at the beginning of the Colony would have prevented this war altogether, and that the leniency of Governor Fitzroy protracted it; and to this I think must be added, that it left but a very slight impression upon the natives of the real power of the British Government.

For the peace that *Heki* and *Kawiti* made at last was not so much forced on them by the fear of punishment from the British force, or despair at losing two or three pahs, as it was rather the result of their usual native customs; a little blood drawn on each side satisfies their honour for the time; and if at any future time an accidental cause of war should excite them again against the British, there will be found plenty of young fellows who, having served in these last campaigns, will not only be ready but anxious to try another campaign *against* the British troops.

To make them really fear the British power will require another system; I do not think any regular troops would ever succeed in doing it. I believe the troops who have served in New Zealand have done as well as regular troops ever did in any country against savages; and with the best equipment could have done very little more. It requires a local corps of men so equipped and trained that they could go wherever the native goes, and for the time live as he lives, come upon him by surprise and take him prisoner. Such a corps would not require guns or drays, or even bags of powder. And judging from some of our troops which had been in one or two campaigns, and from the habits of the settlers, I believe that a corps composed of British soldiers and settlers, so equipped, would after a year or two's training beat the savage out of the field.

The native allies appear to have given more decided support to the British force in this last campaign; they came in greater numbers, and took an active part in the councils of war, and gave very good information and sensible advice. The doubtful natives were, no doubt, encouraged to support our side by the evident

7. RUAPEKAPEKA. — 1846.

determination of the Government to punish *Heki.* They were supplied with provisions, a very proper arrangement, and also with ammunition, which may be necessary to some extent, but requires great caution in issuing, as they not only waste it, but sometimes, according to their own customs, supply the enemy. Governor Grey even persuaded one chief (*Macquarrie*) to make a separate diversion with only his own natives against *Heki*, who was at *Ikurangi*, and which succeeded in keeping *Heki* away from *Ruapekapeka* until the very evening before the capture. The unsteadiness of the native character, their custom of communicating with the enemy, and their rapacity for payment, made Colonel Despard distrust their good faith ; but their presence probably prevented the enemy from disturbing him on the line of march ; and without them he would have had no information. They, no doubt, wished to be friendly to the British Government, but it must be remembered that such allies may very soon be turned away by a few slight mistakes or unintentional offences. Perhaps, therefore, the safest system of using native allies would be to employ them freely in assisting the progress of the forces, and *pay them liberally*, and at the same time show them, as Colonel Despard says, that you are prepared to act independently of them altogether. It seems at first curious how so large a force of natives and troops together should have had so much difficulty in defeating so small a body of natives alone: but the natives did not take a prominent part in the attack, it was not to be expected that they would, and the pah was far stronger than anything they had been accustomed to ; and of the troops, only a small part could be brought to the front in actual contact with the enemy, owing to the nature of the ground ; the greatest part were occupied in overcoming the difficulties of the ground.

Governor Grey thought so highly of the conduct of the native allies, that he laid the foundation of a native corps, by enrolling sixty natives and placing them under British officers. This was afterwards merged into the more useful and practicable corps of *the armed police*, composed of English and natives indiscriminately. I think it would be rather dangerous to raise a corps of natives alone, for no savage can be depended on at all times, and the ties of blood of the *Maori* may cause him to fail in his duty at the very place and time when he is most wanted. But I believe *the armed police* to be the foundation of the most efficient corps any colony could have for the preservation of its internal peace.

The majority of the troops returned to Auckland, leaving about 200 men at the Bay of Islands as a military post, which force has remained there ever since Colonel Despard returned to Sydney.

Governor Grey then turned his attention to the civil government of the colony. He restored the Crown's right of pre-emption of lands from the natives, the waiving of which by Governor Fitzroy was causing such an indiscriminate sale of lands in the north between natives and Europeans as would undoubtedly have led to serious disturbances ; he established magistrates for the execution of British law in a summary manner between natives and Europeans : and under the protection of the strong force now in the Colony he prohibited the importation and sale to natives of arms and ammunition, which former governors had not dared to do, notwithstanding that our enemies were thus supplied. The finances were in a very bad state, partly from the troubles which prevented trade, and partly from the manœuvres of previous governors to raise money. In all these financial difficulties there was this one great fact, which the governors had been trying to get over by various schemes without success,—*The want of money.* It was a difficulty which could be solved in no other way than by a grant from England.

And one of Governor Grey's first acts was to apply urgently for the men and money which Captain Fitzroy had not been able to obtain. Fortunately, as before said, the tide had turned, and they were now both supplied.* 7. RUAPEKAPEKA. 1846.

But there were other military difficulties yet before him. The land disputes in Cook's Straits were still going on, and as far from settlement as ever; and the threats and conduct of the opposing natives had become so violent that Governor Grey went to Wellington in Feb. 1846, accompanied by a strong force.

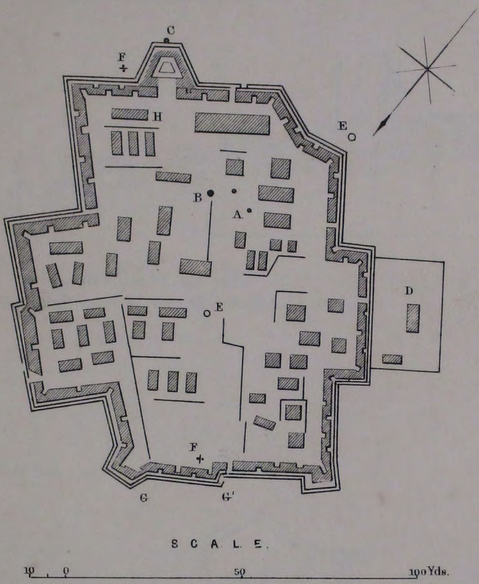
On the 20th of January H.M. steamer "Driver" arrived at Auckland from Sydney (being the first steamer that came to New Zealand), and brought a detachment of the Royal Artillery from England, under Captain Henderson, R.A., with two 3-pr. field guns, and two 12-pr. howitzers.

* B. B. 1846.

END OF PART II.

## THE PAH AT RUAPEKAPEKA.

From Sketches by Capt. Marlow, Lt. Leeds & Mr. Du Moulin.




## References.

A............ *Flag staff (shot away)*

B............ *Do. to replace the above.*

C............ *Another flag staff.*

D............ *Unfinished part of pah.*

E.E.......... *Wells.*

F.F.......... *Guns.*

G............ *Breach made by Batt. Nos. 1 & 2 (32 & 12 prs.)*

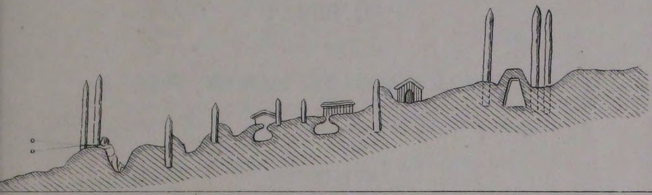
G'........... *Do. by Batt. No. 3. (18 & 12 prs)*

H............ *Kawiti's hut.*

From U.S. May. 1846.

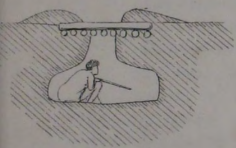
J. R. Jobbins.

RUAPEKAPEKA.

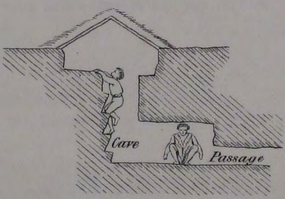


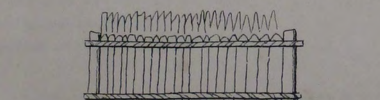
Section of the pah.
Horizontal Scale 60', Vertical Scale 15, to 1 Inch.

Section of a Bomb proof hole.



Section of a hut.



Elevation of Palisades, showing loopholes.

m U. S. Mag. 1846.

J.R.Jobbins.

# PAPER III.

## NEW WORKS AT PORTSMOUTH.

### CONTENTS.


| | | Page |
|---|---|---|
| I. | —Preliminary Remarks and List of Officers Employed in the Royal Dockyards | 77 |
| II. | —Site of Steam Basin | *ib.* |
| III. | —Contracts | 78 |
| IV. | —Geological Foundation on which the Docks and Wharf Walls are built | 79 |
| V. | —Description of the Dams | 80 |
| VI. | —Steam Basin and Section of Wharf Walls | 82 |
| VII. | —Docks in the Steam Basin | 83 |
| VIII. | —No. 8 Dock | 86 |
| IX. | —Factory for the Repair of Steam-engines and for Making and Repairing Boilers | 88 |
| X. | —Brass and Iron Foundry | 92 |
| XI. | —Iron Smithery | 93 |
| XII. | —Boat Store, Chain Cable Store, and Saw Mills | 94 |
| XIII. | —Economy of Labour in the Transport of Materials | 95 |
| XIV. | —Railroads | *ib.* |
| XV. | —Transport of Anchors | 97 |
| XVI. | —Landing, Stacking, and Transport of Timber | 98 |
| XVII. | —Landing and Storage of Coals | 99 |
| XVIII | —Coaling of Steamers | 100 |
| XIX. | —Cost of Works Executed | 102 |


N.B. The plates are referenced according to the above sections.

# PAPER III.

## DESCRIPTION OF THE STEAM BASIN, DOCKS, AND FACTORY, AND OTHER WORKS RECENTLY EXECUTED IN PORTSMOUTH DOCKYARD.

By CAPTAIN H. JAMES, R.E. F.R.S. M.R.I.A. F.G.S. &c.

I. IN consequence of the introduction of steam vessels into the Royal Navy, the importance and necessity of enlarging the Royal Dockyards, and having factories in them for the repair of the machinery of the steamers, with basins, in which these vessels might always lie afloat uninfluenced by the rise and fall of the tide, and with docks designed to suit the peculiar forms of the steam vessels, was soon felt; and the Lords of the Admiralty were pleased to order designs and estimates for very extensive works of the above description, to be prepared under the superintendence of the officers of the Royal Engineers, who were then employed under the Admiralty: they were—

Lieutenant-Colonel Brandreth, R.E., holding the office of Director in Chief of Admiralty works, and having under him the following officers, as Local Directors of Works in the several Dockyards, viz.:—

Captain M. Williams, R.E., at Pembroke,

Captain Burgmann, R.E., at Devonport,

Captain Sir W. Denison, R.E., at Woolwich and Deptford,

Captain Mould, R.E., at Chatham and Sheerness,

Captain Beatson, R.E., at Portsmouth.

Captain Hope, R.E., was sent to Bermuda, to superintend the works required there.

The works first executed were those at Woolwich, under Captain Sir W. Denison, where a most perfect factory establishment, with docks and building slips, have been constructed; and in consequence of the great experience that officer had acquired in the construction of the works there, the Lords of the Admiralty ordered him to Portsmouth to design the works required at that port: but soon after his removal he received the appointment of Lieutenant-Governor of Van Dieman's Land, and the appointment at Portsmouth being offered to me, I gave up the appointment of Director of the Geological Survey of Ireland, which I then held, to accept it, and took charge of the works in that Dockyard, in June, 1846.

### II.—SITE OF STEAM BASIN.

The selection of the best site for the steam basin and factory gave rise to much discussion: one proposition was to enclose the space B,* on the south side of Weovil Creek, and to have the factory close to the Royal Clarence Victualling Yard; the supposed advantages of this site consist in its being on the windward shore, and in its having deep water along its front; but the great inconvenience and cost which would result from having the steam-factory on the opposite side of the harbour from the Dockyard, and from having two distinct establishments

* See General Plan of Portsmouth, No. 1.

for the repair of steamers, which constantly require the shipwrights, the riggers, and the factory people to be employed upon them at the same time, was felt to overbalance any advantage the site had in other respects; and further grave objection was found in the probability that the works to be constructed there, would produce an injurious effect upon the harbours, by the deposits which would be caused by the deflection of the tidal currents from their present course.

Another site proposed was that at A (see plate I.), where the timber ponds now are, between the Dockyard and the gun wharf, and in front of the Common Hard; this site possesses many great advantages; it is near the mouth of the harbour; there is deep water along its front, and it would have connected the gun wharf with the Dockyard, but without projecting the works so far into the harbour as would be likely to produce injurious effects, it was found that this site did not afford the space required for the works then contemplated, and reserving room for further enlargement if hereafter required.

The site, therefore, at the north end of the Dockyard was finally decided on, though it led to the necessity of purchasing some ground, and a considerable number of houses.

The plan of the basin and docks, as designed by Sir W. Denison, will be understood from the Plan (plate II.); in this design the factory was placed on what is now called the Battery Ground between the two Inlet Docks; it was also intended to have a double dock, separated by a caisson, extending from the entrance to No. 7 Dock, to the harbour, to serve as another entrance to the basin, and as a lock by which steamers might be taken in at a low state of tide. The supposed immediate side of the basin; the design for the double dock was also abandoned at the necessity for a factory in 1847, led to the abandonment of the projected site for it, the ground not being then enclosed from the harbour or made up, and I was ordered to prepare new designs for the factory in its present site along the west same time.

It is greatly to be regretted that any alteration was made in the designs prepared by Sir W. Denison,* as it provided ample room for the factory establishment, and for its enlargement if hereafter required; and it was admirably arranged in reference to the basin and the docks on either side of it. By altering that design, and building the factory on its present site, the ship-building department and the factory department are brought together on a spot of ground which is much too small for them, and led to the necessity of remodelling the plan of every building on that ground.

### III.—Contracts.

A contract was entered into with Peter Rolt, Esq., for the execution of the greater part of the works required, and with Benjamin Bramble, Esq., who had previously executed a great deal of work in Portsmouth Dockyard for the remainder, Mr. Bramble's schedule of prices being amended to meet the class of work which was not included in his original contract. The schedules of prices were prepared with great care, but not sufficiently so to obviate many disputes as to the right interpretation of the items; and I quote one claim as a remarkable example of the importance of extreme care in preparing such documents, and because the mere omission of a comma gave rise, in this instance, to a claim for the sum of near 10,000*l.* :—

* In which he had the able assistance of Andrew Murray, Esq., C.E., the chief engineer for machinery.

Item 95 of Mr. Rolt's contract is as follows:—"Riga, Dantzic, or Memel fir timber, in piles . . . . . . . . 1s. 10d. per foot cube."

A vast quantity of this kind of timber was required for the dams, and provision was made in the schedules, in Item 121, for returning the timber to the Contractor at a given price after it had been used, if the Admiralty should not wish to keep it.

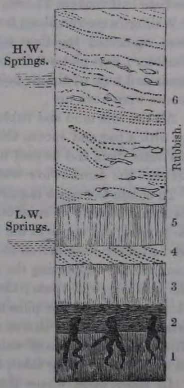
Item 121—"All timber having been used and not required by the Crown to be taken back by the contractor . . . . . . . 6d. per foot cube."

The Admiralty decided on keeping the timber which had been used, upon which Mr. Rolt claimed, under Item 121, to be paid 6d. per foot for all the timber which had been used, in addition to the price of 1s. 10d. it had been previously paid for at; Mr. Rolt contending that because he had not been required by the Crown to take back the timber as his own property, he was entitled to the extra price of 6d. for every foot which had been used.

Had there been a comma after the word Crown, this claim could not have been made. The Admiralty submitted the claim to the arbitration of Mr. Brunel, the eminent Civil Engineer, and to the Law Officers of the Crown, who gave it as their opinion that Mr. Rolt had no claim: but that gentleman has not yet abandoned the hopes of getting his claim allowed.

## IV.—Geological Notice of the Foundation on which the Docks and Wharf Walls are built.

The lowest stratum of the section exposed in the excavation of the steam basin, is a bed of tenacious brown clay, which was identified by its fossils as one of the beds of the London clay. The "mottled clays," which are below the London clay, crop out at Stamshaw to the north of the Dock Yard, and between it and the chalk at Portsdown Hill. This mottled clay, which is of a bright red colour (from the great quantity of the peroxide of iron which it contains) from its great tenacity and weight, proved to be a most valuable substance for filling the dams, and keeping out the water.




The annexed section will explain the strata which were laid open in the excavation.

No. 1.—The "London clay," on which the docks and wharves were built.

No. 2.—A stratum of peat 2 feet thick, with the stumps of trees and their roots, *in situ* as they grew: this stratum was in one place, at No. 8 Dock, 29 feet below the level of high water spring tides; and, taken in connexion with the observations made all round the coasts of England, Ireland, and the adjacent coast of France, prove a general subsidence of the land over a very large area, and, geologically speaking, within a very recent period; but there is evidence in the vast masses of drifted materials, such as the flints and gravel and sand which have been accumulated upon these forests (at Cromer, in Norfolk, it is 400 feet deep), that these remains of forests have been depressed and submerged many hundreds of feet, and that they have been brought up to the present level by a subsequent elevation of the land.

No. 3.—A bed of estuary clay, 4 feet thick, similar to that in the harbour, and containing shells of the same species of mollusks as now live.

No. 4.—A bed of shingle, 18 in. thick.

No. 5.—Another bed of estuary clay of the same character as No. 3.

No. 6.—An irregular mass of chalk flints and gravel and rubbish.

### V.—Description of the Dams. Plate V. 1.

The entire length of the principal dam was 2256 feet: it extended from No. 4 Slip to the circular tower at the end of Frederick's Battery, and excepting in those places where there was a break in the line of the works, as at the entrance to the steam basin, was constructed parallel to the wharf wall at about 6 feet from the foot of it.

The dam was constructed by driving a double row of piles, and filling in the intermediate space with Stamshaw clay.

The inner row of piles were all of whole timber driven close to each other, and caulked to form perfect watertight joints; the outer row consisted of gauge piles of whole timber driven 4ft. 6 in. in front of the inner ones, and at intervals of 12 ft. 9 in. from centre to centre, the intermediate spaces being closed with half baulk timbers driven so as to form close joints throughout.

The inner piles stood 5 feet above the ordinary spring tides, and were about 45 feet long, which allowed for about 10 feet in the ground when the excavation for the foundations was taken out.

The outer row of piles were only at the level of neap tides, about 10 feet below the level of the inner dam: the gauge piles were 25 feet long, and the intermediate half timbers 21 feet.

Walings were run along both the outer and the inner dams, and the two dams were connected together with iron tie-bolts, through the gauge piles, 2¼ inch diameter; iron plates 9 inches square and ¾ inch thick being placed under the heads and nuts of the tie-bolts, to prevent their sinking into the timber when the screws were hove up.

All the soft mud and rubbish between the two dams was excavated or dredged up with a bag and spoon, and the space filled with Stamshaw clay to the level of the outer dam, and formed up with a slope to prevent a lodgement of the water between the dams at low water.

To obtain the space required for the construction of the wall, with its counterforts, and backing of concrete, 21 feet were necessary, at which distance from the inner dam, and opposite the centre of the space between the gauge piles, piles of whole timber were driven to serve both for the abutments of the shores to the dam, and for supporting the retaining planks where the nature of the soil behind the wall required them; the space between the direct shores was supported by oblique shores to the piles in the rear, as shown in Plate V. 1; which shows the arrangement of the shores when the dam was at some distance from the work. There were four lines of waling, and rows of shores required. The first row was at the level of spring tides, the others were at 8 feet apart.

In those cases where the dam was at a considerable distance from the work intermediate piles had to be driven, through which the lines of shores were carried till some sure abutment was reached; and such was the pressure upon these piles in some instances, that they were entirely crushed and twisted off.

As soon as the masonry was finished, the outer dam was drawn and entirely removed, but the inner dam was cut off with a circular saw at the level to which the dredging was carried; in cases where the inner piles of a dam have been drawn, and a trench thus formed along the foot of the wall, the wall has settled and been much injured, as might be naturally expected. A 14 cwt. monkey was used in driving the piles in the dam, which, with a fall of 20 feet, drove from a $\frac{1}{4}$ to $\frac{3}{8}$ of an inch at each blow.

### Cost of the Dam.

The prices paid were as follows :—

| | | £ | s. | d. |
|---|---|---|---|---|
| Fir in piles | per foot cube | 0 | 1 | 10 |
| Driving ditto | ,, | 0 | 0 | 5 |
| Shoes, and hooping | per cwt. | 1 | 2 | 0 |
| Fir in shores, walings, braces, struts, all labour and waste | per foot cube | 0 | 2 | 5 |
| Screw bolts, nuts, and plates | per cwt. | 1 | 5 | 0 |
| Spikes of sorts | ,, | 0 | 19 | 6 |
| Excavating between dams and barging away, | per ton | 0 | 1 | 3 |
| Stamshaw clay puddled | per ton | 0 | 2 | 2 |
| 3 in. retaining plank fixed | per foot superficial | 0 | 0 | $7\frac{1}{2}$ |
| Excavation and barging away | per ton | 0 | 1 | 2 |

### Cost of Removal of the Dam.

| | | | | |
|---|---|---|---|---|
| Taking out and barging away clay | per ton | 0 | 1 | 5 |
| Unbolting, cutting off or draining piles, and removing all iron work | per foot cube | 0 | 0 | 4 |

The cost per foot run of the dam, and its removal, where it was of the simplest form, as before described, was 17*l.* 12*s.* 6*d.*, but as the nature of the ground varied in different parts of the work, so it was found necessary to vary the length and dimensions of the piles; so also, in some instances, the shores extended in lines upwards of 100 feet; the above cost must not, therefore, be taken as the average cost per foot run.

### Accident to the Main Dam.

It could hardly be expected that a dam of such a great length as 2256 feet, and with the pressure due to upwards of 30 feet of water against it, could be preserved from accident during the whole progress of the works, particularly when it is considered how constantly the shores have to be shifted; in truth, from first to last the maintenance of the dam in a perfect state was a constant source of anxiety to all engaged upon the works, and called for our closest attention both by day and night.

I am induced to describe an accident which occurred on a Sunday, when there were no workmen in the Dockyard, which threatened to cause the filling of the steam basin long before the foundations were all in, and which would not only have caused a very great delay in the progress of the works, but also the loss of several thousands of pounds, because the experience thus gained may be of service to others who may hereafter be engaged on similar works.

It was reported to me that the dam, at the circular part of the sea-wall, near No. 8 Dock, was falling outwards, and that the piles were cracking and giving way. I ran to the spot as fast as I could, turning in my mind what resources I could command in such an emergency. I saw that the report was correct, the dam had fallen bodily outwards 3 ft. 6 in. from the perpendicular, and eight or nine piles in succession were cracked, the upper shores were falling out, or hanging loose in the cleets.

If immediate steps were not taken it was clear we should have the most serious accident that could possibly happen to us, and this at a time when we were almost daily urged to press on the work with all possible dispatch; I therefore went immediately on board the since ill-fated "Avenger" steamer, then commanded by Captain Dacres, and demanded the assistance of his whole crew, which he at once acceded to, and came himself with his officers to superintend them. Captain Chads, also, soon afterwards sent one hundred men from the "Excellent," to assist us. By the aid of the sailors we had five lengths of chain cable passed round the dam, each length taking up a certain portion of the dam, the ends being brought in and tightened up with double purchase tackles, leading from some piles which were standing in No. 8 Dock, near the centre of the curve of the dam.

Messengers had been sent round the town to get in, also, as many workmen as could be found, to place in additional walings and shores along the foot of the dam, to prevent its coming in; and in this way, by holding the head of the dam in its place, whilst the foot was shored to prevent its coming in, and by working incessantly till two o'clock in the morning, I had the satisfaction of seeing that we had passed the highest spring tide without further accident.

When I came to consider the cause which led to this accident, and the peculiar manner in which the dam gave way, I found that the third tier of shores were abutting upon the masonry of an old wall, and could not yield in the slightest degree, whilst on the contrary the lower tier of shores were abutting on baulks of timber against the clay under the foundation of the old wall, and as these abutments yielded in some degree whilst the tier above remained fixed, the piles of the dam turned, so to speak, upon fixed points, throwing the upper part of the dam outwards—a movement which the weight of the clay in the dam would accelerate when it was off the perpendicular.

### VI.—Steam Basin and Section of Wharf Walls. Plate VI. 1.

The length of the basin, measured along the front of the factory, on the west side, is 1000 feet, the side opposite is 600 feet long, and the breadth 400 feet. The area of the basin is 7 acres. The depth of water, at high water neap tides, is 21 feet over the invert at the entrance, and 29 feet at high water spring tides; so that the largest steamers can be taken in on any day throughout the year.

The breadth of the wharf wall at top is 5 ft. 6 in., and at the bottom 11 feet, the batter being $\frac{1}{8}$ or $1\frac{1}{2}$ in. to 1 ft. See plate VI. 1, for full details of construction. The beech bearing-piles on the foundation are 14 feet long, but in consequence of the treacherous nature of the ground at the north-west angle, outside No. 8 Dock, whole baulks of timber, 40 feet long, were driven for sustaining the wall at that part of the work. The courses of granite ashlar throughout the greater part of the work are laid with alternate headers and stretchers; but the late Lieutenant-Colonel Irvine, C.B., of the Honourable East India Company's Engineers, when he succeeded Colonel Brandreth, ordered the wall to be finished with two stretchers to one header, and that part of the wall outside No. 8 Dock, and the part near the circular tower at Frederick's Battery is so built. This alteration was made on the score of economy; the size of the stones in the granite facing was ordered to be reduced for the same reason. This alteration was made in opposition to my judgment, as the saving in the cost was very trifling, and the stability of the wall was thereby endangered.

| | £ | s. | d. |
|---|---|---|---|
| The cost of the wall per foot run where it was straight was . | 33 | 18 | 6 |
| The cost of the dam and its removal per foot run, was . . | 17 | 12 | 6 |
| Making a total per foot of . . . . . . . . . . | 51 | 11 | 0 |

From the form of the entrance to the basin, vessels are taken in and out with great facility; the length of the wharves both inside and out give great accommodation for the steam vessels under repair, and for others bringing stores, &c.; these advantages will be fully appreciated whenever there is a great press of work.

The form of the entrance to the basin is similar to that of No. 7 Dock. See Plate VII. It is closed with an iron caisson, made by the Messrs. Fairbairn, the cost of which was 5260*l.* The groove for the caisson is 2 feet wide, with the sides perpendicular to the face of the work, and in a perfect plane; this mode of construction insures a perfect contact with the keel of the caisson, even if the caisson is a little out of its true position; if a batter is given to the groove, the slightest deviation from the exact true position of the caisson necessarily forces the surfaces apart, and causes a leak: this is not of much importance for a basin, but leads to great inconvenience in a dock. The depth of the groove is 1 foot, and it is lined with iron plates planed perfectly smooth up to low water-mark. The fitting of a caisson requires extreme accuracy in the work, but once attained, the pressure of the water ensures the preservation of the perfect contact of the surfaces of the keel and groove. When the caisson to No. 7 Dock was fitted to its place, not one single drop of water leaked through the joint.

The estimated cost of the basin was 240,000*l.*, and the time named for its completion was five years. The first stone was laid by Rear Admiral Hyde Parker, C.B., on the 29th May, 1843; the last stone was laid on the 25th May, 1848, by Colonel Irvine and myself, in presence of Her Majesty, who came in state attended by His Royal Highness Prince Albert, the Duke of Wellington, the Marquis of Anglesey, Lord Auckland, and the other Lords of the Admiralty, Admiral Sir Charles Ogle, the Commander-in-Chief, Rear-Admiral Prescott, C.B., the Superintendent of the Dockyard, and a great number of other distinguished persons, and a vast concourse of people assembled from all parts of the kingdom.

The actual cost of the basin was 242,000*l.*, and it was finished five days before the time named for its completion. So close an agreement between the estimated and actual cost of a work of such magnitude, and the estimated time for its completion, is almost without precedent.

### VII.—Docks in the Steam Basin. Plates VII. 1, 2, 3, 4, 5.

It will be seen by reference to the plan, that there are three docks leading out of the basin; these are known as No. 7, or Camber Dock, the North Inlet, and the South Inlet Docks.

The entrances to the steam basin (see plate VII. 3), and to No. 7 Dock, have been made with a sufficient breadth and depth for the largest steamers, with all their armament, stores and coals on board, to be taken in at the lowest neap tides. The great breadth of the steamers with paddle-wheels, and the proportionally still greater length of those with screw propellers, has led to the necessity for constructing the new docks with dimensions much greater than is required for those intended to receive the largest three-deckers in the navy; thus whilst the length of the largest of the old docks is 264 feet, No. 7 Dock is 292 feet long from the caisson to the head of the dock; and whilst the breadth of the entrance to the one is only 57 feet, that of No. 7 is 80 feet.

### No. 7, or Camber Dock.

The entire length of this dock is 323 feet, including the breadth of the invert, which is 46 feet broad.

The length of the floor from the invert to the first altar at the head of the dock is 244 feet, the breadth 37 feet. The floor is slightly rounded from the centre to carry off the water to the gutters along the sides, and by which it passes into the reservoir. The continuous broad altar round the dock is 7 feet wide; this gives space for the paddle-wheels, and gives also great convenience to the shipwrights employed upon the repairs.

It will be seen by the longitudinal section, that the floor of this dock is nearly on a level with that of the invert, whilst the usual mode of constructing docks is to keep the floor at about 2 feet below this level, by which means a vessel that can be just floated in is brought on blocks 2 feet high; this deviation from the usual mode of construction was necessary in consequence of the level of the reservoir into which the water from the dock runs when it is being emptied, and which is only a few inches below the level of the entrance.

The breadth between the vertical faces of the broad altars is 70 feet, and the extreme breadth 100 feet.

The depth of the dock from the coping is 32 feet, and the depth of water at high water neap tides is 21 feet, which is sufficient for the largest steamer in the navy.

The detail of the construction will be best understood from the drawings :—

No. VII. 1.—Is the plan of the dock, as finished.

No. VII. 2.—Plan of the piling, transverse and longitudinal sleepers, and of the planking under the invert, and longitudinal section of the dock.

No. VII. 3.—Section across the entrance, showing the construction of the inverted arch.

No. VII. 4.—Transverse section of the docks through the altars.

No. VII. 5.—Transverse section through the timber slides, and elevation of the end of the dock.

The dock is built on the close tenacious "London clay" before described. The beech bearing-piles, under the invert, are driven at intervals of 4 feet from centre to centre; and under the floor of the dock, at intervals of 5 feet from centre to centre, they are 15 feet long; a grillage of longitudinal and transverse sleepers is framed on upon the heads of the piles, and secured to them by oaken treenails. The clay was excavated to the depth of 2 feet below the under side of the sleepers, and this space filled in with concrete to the level of the underside of the sleepers; the spaces between the sleepers were then filled in with bricks set in cement, and hoop-iron laid crossways to complete and strengthen the bond. In addition to the bearing piles, rows of close sheet piles were driven on both sides of the invert at the entrance, to prevent the passage of water under the work, and fir planking 8″ thick was also laid upon the sleepers under the invert. In this way a perfect floor was prepared for the reception of the masonry, The lining of the dock is constructed entirely of the best Cornish granite; the radii for the curves of the invert, the forms of the blocks of stone, the nature of and the manner in which the backing was carried up, will be better understood from the sections than from any verbal description: I therefore refer to them for further detail.

The dock is closed with an iron caisson, built by the Messrs. Fairbairn, the cost of which was 5260*l.*; the inner face of the groove for the keel of the caisson is lined with cast-iron plates, secured to the masonry by dovetails run in with lead; the plates were planed perfectly true, but the operation of bringing them into a perfect vertical plane across the whole invert was a difficult and tedious operation; but this was so perfectly accomplished, that when the also perfectly plane face of the oaken keel of the caisson (which is secured to the iron keel) was brought up to it by the pressure of the water, not a drop of water leaked through.

The estimated cost of this dock was 87,000*l.*, but in consequence of the alteration in the design, to which I have before alluded, the actual cost was only 63,263*l.* It was finished and opened with the "Sidon" steam frigate, in August, 1849, the first vessel which went into it for repair.

The following instance will prove the absolute and imperative necessity for having docks of this description in our Government Dockyards. H.M. steam frigate "Terrible," shortly after the completion of this dock, struck on a rock in Plymouth harbour, which made it necessary that she should be docked; but there was not a single dock at that port of sufficient dimensions to take her in, and in consequence she had to be brought to Portsmouth, where, though at neap tides, she was taken into this dock with all her stores on board, and quickly repaired and made ready for sea again. To be prepared for the casualties of war, it is impossible to overrate the importance of having such docks; the new works at Keyham are now rapidly advancing, and it is hoped this want of docks at Plymouth will not much longer be felt.

### North and South Inlet Docks.

The chief engineer,* under whose superintendence all the repairs to the machinery of the steamers are made, being of opinion that the two Inlet docks, between which, according to the original design, the factory would have stood, should be constructed in such a manner that the steamers in them should be as close as possible to the wharves, in order that the heavy machinery might be taken in or out with the greatest facility, these docks were designed in such a manner as to meet his views, and to serve as inlets from the steam-basin in which the steamers under repair might lie close to the factory, and to be used as docks only when repairs were required to any part outside the vessel which was below water, such as to the screw or propelling-shaft, pipes, &c.

The breadth at the entrance of these docks is 70 feet at the coping, and 56 feet across the floor; the depth from the coping to the invert at the entrance is 29 feet; thus it will be seen that the latter is as nearly as possible ¼, which gives a 9-inch step or altar for every 3 feet of rise, which will answer well for shoring the vessels, and for the workmen to get down to their work, and for every purpose for which these docks were designed.

* Mr. Murray, C.E.

The entrances to these docks, and 70 feet of the floors, the sides being racked back, have been constructed; but in consequence of the change in the design for the factory, and a change in the views of the Lords of the Admiralty as to the necessity for immediately completing these docks, they have been left unfinished, though a great deal of the material for completing them has been accumulated in the Dockyard.*

### VIII.—No. 8 Dock.†

The position of this dock at the north-west corner of the dockyard will be seen by reference to the plan.

The dimensions of this dock differ materially from that of the others. It was considered desirable that it should be made in such a manner that all classes of vessels might be taken into it; and particularly that it should have sufficient length for the enormously long screw-steamers which are now being constructed.

The length of the deck of the iron steamer "Simoom" is 259 feet, whilst she has only a breadth of 40 feet. To provide for receiving such vessels, and possibly for even longer ones, the entire length of the dock had to be built 334 feet long, or 295 from the invert, at the entrance, to the head of the dock. The length of the floor inside the invert is 242 feet; the breadth of the floor is 36 feet. The breadth of the entrance is 65 feet, with 23 feet depth of water at ordinary spring-tides, and 19 feet at neap-tides. This dock was intended for vessels having to undergo considerable repairs, and as, when lightened, the largest vessels can be taken into it (the paddle-wheels of the largest steamers passing over the coping-stones at the entrance), all the conditions required have been fulfilled, though the position of the dock is not a good one. The first ship taken into it was the "Britannia," of 120 guns.

The sides and bottom of the entrance to this dock are straight, with a batter of 1½ inch in a foot, instead of being made with a curve, as in No. 7 dock. This construction is more simple, and if the groove for the caisson is made vertical, the fitting of the caisson is more readily effected; but the groove was ordered, against my judgment, to be built with a batter, so that the sides incline to one another like the sides of a picture-frame, and a movement of the caisson on either side must necessarily cause an opening.

The detail of the construction of this dock is so fully explained in the plates that I think it unneccessary to give it in writing.

No. VIII. 1. Is the plan of the dock finished.

" VIII. 2. Is the plan of the bearing-piles, and sheet-piles on either side of the invert and of the transverse and longitudinal sleepers, and a longitudinal section of the dock.

" VIII. 3. Is the section across the entrance.

" VIII. 4. The section through the altars.

" VIII. 5. The section through the timber-slides.

This dock is so far removed from the reservoir through which the water has to be pumped, that, to find the requisite fall for the water through the long culvert from it, it was necessary to keep the level of the dock above that of No. 7, and consequently there is not the same depth of water in it by two feet as in No. 7. This is one of the consequences of its defective position, and makes this a less useful dock than could have been wished. The culvert from this dock

* Since the above was written I have learned that orders have been given for completing the South Inlet Dock, according to the section of No. 7, and 300 feet long.

† No. 9 in the Parliamentary Estimates.

runs under the altars on the south side of it, and from thence along the head of the building slips to the head of No. 7 dock, and from thence along the south side of that dock, entering the reservoir at the same point that the culvert from No. 7 does; a branch from this culvert leads to the pump-well in rear of the factory. By this arrangement all the docks in the yard are put in connection, not only with the same reservoir, but all the docks may be emptied by the pumps at the factory engine, as well as by the pumps at the reservoir; an arrangement which I have no doubt will prove highly beneficial in the working of so many docks.

The estimated cost of this dock, including an iron caisson, for which Mr. Fairbairn's tender was 3,500*l.*, was 81,536*l.* The actual cost of the dock was 77,341*l.* But a wooden caisson having been ordered instead of the iron one, at a cost of 6,680*l.*, the cost was made 84,021*l.*, which includes the cost of the culverts, to the reservoir.*

### Comparative Advantages of the Screw and Paddle Wheels as Propellers.

Whilst engaged in executing these works, rendered necessary by the introduction of steam-power into the navy, and seeing the daily progress made in introducing the screws for propelling vessels of every class, one could not but feel that we were executing costly and permanent works for a class of vessels which, in a few years, may become obsolete.

The great space occupied by the paddle-wheels prevents an effective armament being given to vessels of war with them, whilst their uncertain action in a cross sea, and their exposure to the force of the waves and of the wind, must necessarily retard their speed; but what is still of more importance, the wheels, the shafts, and connecting machinery, being necessarily high out of the water, expose them to the fire of an enemy, with the prospect of their being crippled at the very commencement of an action.

The screw-propeller, on the contrary, leaves a clear deck for a perfect armament, whilst the propeller and all the machinery is below the level of the water, and is thus protected from the effect of shot from an enemy, so that, supposing the speed of the screw-propelled vessels was equal to that of those with paddle-wheels, there seems no doubt as to which the preference should be given for vessels of war; and in this last particular they are now scarcely, if at all, inferior to those with paddle-wheels.

The necessarily fine run which has to be given to vessels with screw-propellers, to ensure their full effect, leads to consequences not favourable to them, as the sterns of the vessels are necessarily left without that support which their own weight, the weight of the screw itself, and of the heavy guns now mounted on the quarter-decks of steamers require; the great length of the connecting shafting also, with the high velocity at which it has to be turned upon numerous bearings, are objections to the screw-propellers which it is desirable should be overcome. And I look with confidence to the time when they will be overcome, by having propellers under water, near the centre of the ship, and in close direct connection with the machinery. Still, with the existing defects in the screw-propelled vessels, there cannot be a reasonable doubt as to their superiority over paddle-wheel steamers for vessels of war.

* This dock was built by B. Bramble, Esq.

## IX.—Factory for the Repair of Steam Engines and for Making and Repairing Boilers. Plates IX. 1, 2, 3, 4, 5, 6, 7, 8.

It was originally intended that the factory should have been on the east side of the steam basin, between the two inlet docks, in which position four steamers might have laid afloat close to the shops where the repairs of their machinery were carried on; but in consequence of the pressing demand for a factory, and the state of the works on the east side not admitting of its being immediately built there, the Lords of the Admiralty altered the original plan, and ordered the factory to be built along the west side of the basin.

In this position we have a frontage of 800 feet from the entrance to No. 7 dock to the entrance to the basin—this enabled us to appropriate 687 feet for the entire length of factory, but in consequence of the proximity of the buildings in the rear of this site, after reserving a clear wharfage of 42 feet along the front, we were only able to appropriate 38 feet 9 inches to the interior breadth of the building, which we should otherwise have made at least 45 feet broad. The factory is 48 feet 6 inches high from the ground to the spring of the roof, divided into two stories, the ground floor being 30 feet 6 inches high to the under side of the girders, and the upper floor 14 feet 9 inches to the tie-rods of the roof. By reference to the plan of the ground floor, it will be seen that the building is divided into five equal compartments; the two northern, on the ground floor, are for the construction and repair of boilers; the centre is for punching and shearing the plates of iron used in the construction of the boilers; the southern compartment is for heavy turning, and that next to it for erecting the engines previous to their being put into the steamers.

The upper floor is appropriated for the light turning and fitting shops, for the pattern makers, pattern store and mould loft, where the designs for the boilers are drawn to their full size on the floor.

Cast-iron circular staircases (see plates IX. 7, 8), lead from the lower to the upper shops, in addition to which there are "lifts," by means of which the men, as well as the work upon which they are employed, are readily raised or lowered from one floor to the other by the power of the engine.

The following is a list of the machines in the several workshops, all of which are worked by an eighty horse-power steam-engine, which is in the building to the rear of the centre of the factory, from whence a shafting is led under ground into the factory, and from thence to every part of the building where power is required.

| Shops. | Description of Machines. | No. | Height of Headstocks. | Length of Bed. | Centres capable of Turning. | Capable of Planing. | Stroke of Slotting Machine. | Lift of Cranes. |
|---|---|---|---|---|---|---|---|---|
| Heavy Turnery. No. 1. | Heavy turning lathes | 1 | 55 inches | 26 feet | 20 feet | | | |
| | | 1 | 44 „ | 40 „ | 12 „ | | | |
| | | 1 | 33 „ | 16 „ | | | | |
| | Smaller do. | 1 | 20 „ | 30 „ | | | | |
| | | 1 | 18 „ | 30 „ | | | | |
| | | 1 | 18 „ | 16 „ | | | | |
| | | 1 | 16 „ | 30 „ | | | | |
| | Large planing machine | 1 | ... ... ... | 20 „ | ... ... ... | 5 ft. × 5 ft. | | |
| | Smaller do. | 1 | ... ... ... | 12 „ | ... ... ... | 4 × 4 | | |
| | | 1 | ... ... ... | 12 „ | ... ... ... | 2·5 × 2·5 | | |
| | Large slotting machine | 1 | ... ... ... | ... ... ... | ... ... ... | ... ... ... | 2 ft. 6 in. | |
| | „ drilling machines | 2 | | | | | | |
| | Shaping and planing do. | 1 | | | | | | |
| | Grindstones | 2 | | | | | | |
| | Travelling crane | 1 | ... ... ... | ... ... ... | ... ... ... | ... ... ... | ... ... ... | 20 tons |
| Erecting Shop. No. 2. | Drilling machines | 2 | | | | | | |
| | Travelling crane | 1 | ... ... ... | ... ... ... | ... ... ... | ... ... ... | ... ... ... | 20 tons |
| | Elevator | 1 | | | | | | |

### Description of Machines in Punching and Shearing Shop, No. 3.

4 Punching and shearing machines, 18 feet bed.
1 Small lathe, 12 feet bed, 9 in. headstock.
1 Shaping machine.
2 Radial drilling machines.
2 Drilling machines (large).
1 ditto (small).
1 Plate bending machine.
2 Grindstones.

### Boiler Shop, No. 4.

1 Punching and shearing machine.
1 Riveting machine.
2 Travelling cranes to lift 20 tons.

### Boiler Shop, No. 5.

1 Shearing machine.
1 Riveting ditto.
2 Travelling cranes to lift 20 tons.

### First Floor (south end), No. 1.—Description of Machines, etc.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Lathe, | 18 | feet bed, | 16 | in. headstock. | |
| 3 | „ | 14 | „ | 10 | „ | |
| 1 | „ | 12 | „ | 9 | „ | |
| 1 | „ | 9 | „ | 10 | „ | |
| 1 | „ | 8 | „ | 16 | „ | |
| 1 | „ | 8 | „ | 12 | „ | |
| 1 | „ | 8 | „ | 9 | „ | |
| 3 | „ | 7 | „ | 6 | „ | |

1 Small lathe, 18 in. bed, 3 in. headstock.
4 Screw cutting machines.
3 Drilling machines.
1 Slotting machine, 9 in. stroke.
1 Shaping machine.
1 Planing machine, 9 feet bed, to plane 3 feet 6 in. × 3 feet 6 in.
1 „ 4 feet bed, to plane 2 feet × 2 feet.

### Light Turning and Fitting Shop, No. 2.—Description of Machines.

1 Lathe with double headstocks, 30 feet (bed) long, 9 and 15 in. centres.
1 „ „ 30 feet long, 14 in. centres.
1 „ „ 24 „ 9 „

| | | | | | |
|---|---|---|---|---|---|
| 1 | „ | 9 | in. headstock, | 8 | feet bed. |
| 5 | „ | 7 | „ | 7 | „ |
| 1 | „ | 6½ | „ | 4 | „ |
| 2 | „ | 9 | „ | 30 | „ |
| 1 | „ | 12 | „ | 30 | „ |
| 3 | „ | 20 | „ | 14 | „ |

4 Small drilling machines.
1 Large ,,
2 Slotting machines, 9 in. stroke.
4 Shaping machines,
1 Planing machine, 4 feet bed, to plane 2 feet × 2 feet.
1 Grindstone.

October 18th, 1850. Portsmouth Steam Factory. Light Turning and Fitting, No. 3.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Lathe, | 8 feet | 6 in. bed, | | 13 in. headstock. | |
| 1 | ,, | 30 | | ,, | 14 | ,, |
| 1 | ,, | 16 | | ,, | 14 | ,, |
| 2 | ,, | 14 | | ,, | 12 | ,, |
| 3 | ,, | 7 | | ,, | 7 | ,, |
| 1 | ,, | 7 | | ,, | 8 | ,, |
| 2 | ,, | 8 | | ,, | 8½ | ,, |
| 1 | ,, | 10 | 6 | ,, | 8 | ,, |
| 1 | ,, | 12 | | ,, | 9 | ,, |
| 1 | ,, | 20 | | ,, | 14 | ,, |
| 1 | ,, | 14 | | ,, | 13 | ,, |
| 1 | ,, | 16 | | ,, | 14 | ,, |
| 1 | ,, | 16 | | ,, | 17 | ,, |

3 Screw cutting machines.
3 Drilling machines.
2 Planing machines, 4 foot bed, to plane 2 feet × 2 feet.
1 ,, 4 foot bed, to plane 11 inches × 18 inches.
1 Grindstone.

Pattern Shop, No. 4.

1 Segment cutting machine.
2 Circular saws.
1 Lathe, double headstock, 24 feet bed, headstock, 13 in. centres.
2 Lathes, 4 feet bed, 5½ in. headstock.
1 Lathe to turn 6 feet.
1 Grindstone.
1 Glue kettle, heated by steam.

No. 5 Room is divided, one half for pattern store, the other drawing floor for laying down boilers full size.

The plans, elevations, and section of the building (see plates IX. 1, 2, 3, 4, 5), will explain the general construction. In taking out the ground for the foundations, it was found there had been so much making up of ground in this part of the yard at some former period, with chips, shavings, and rubbish of all kinds, upon which it was impossible to build, that it became necessary to remove it all until we came to the substratum of clay which at the southern end was at about the depth of 11 feet from the surface, and at the northern at no less than 27 feet 6 inches; we had, therefore, to use a vast quantity of concrete, to bring it up to the level for receiving the brick-work; but it is satisfactory to know, that although the brick-work was immediately proceeded with after the concrete was in, there has been no perceptible settlement throughout the length of this great building. The plinth of the building is of grey Cornish granite; the cornice, window-sills, and rustication round the doorways, are of Portland stone; the roof is of corrugated galvanised iron on a wrought-iron frame, with louvres for ventilation; the window and door-frames are of cast-iron, the lower part of the doors are filled in with corrugated iron plates,—the doors are 14 feet broad and 19 feet high to admit the boilers and large machinery. The floors are supported on cast-iron girders 11 feet 4 inches, from centre to centre, with smaller ones 6 feet 8½ inches, from centre to centre, fitted into snugs or the main girders; the spaces between the girders are filled in with brick arches, backed with concrete, upon which sleepers are laid for carrying the 3-inch plank floor of the upper story (see plate IX. 6). The main girders are 3 feet deep, the lower web is 17 inches broad and 3 inches thick; the estimated breaking weight at the centre being about 100 tons, they were subjected to a proof of 30 tons at the centre; the smaller girders are proportionally strong, and although it may be thought that an excessive amount of strength has been given to these girders, those who have seen the rows of iron columns along the centre of the floor, and the enormous weight of the machinery, and the piles of iron which are sometimes laid on the floors, and consider that so much machinery cannot be set in motion without imparting a certain amount of vibration to the floors, will feel that no greater amount of strength has been given to the girders than prudence would justify.

The estimated cost of the building was 50,500*l.*, but owing to the great depth to which the foundation had to be carried, and the great cost of the foundations for the various large machines erected in the shops, not estimated for, the total sum paid to the contractor was 60,347*l.* 8*s.* 9*d.*

In preparing the designs for this building, provision has been made for an enlargement of the factory to nearly double its present size, at comparatively speaking a very small cost: this may be done by erecting sheds for making the boilers in, and then appropriating the north end of the present building for an extension of the factory, and as such lofty rooms would not be required in that part of the factory, corbels have been built into the walls, and landings provided in the staircases for intermediate floors in such of the compartments as they may be required; and considering the gradual increase in the number of steamers in the Royal Navy, and the great probability that many years will not elapse before auxiliary screw-propellers are introduced into all our men-of-war, this extension may be soon called for.

### X.—Brass and Iron Foundry. Plates X. 1, 2, 3, 4, 5.

These are in one building (at N), the breadth of which is 90 feet, and the length 110 feet; it is divided along the centre by a partition wall, against which the fires for melting the brass are ranged, and along which the flues are led to the chimneys (see plates X. 1, 3, 4).

In the iron-foundry there are two cupolas and an air furnace; in the larger of the two cupolas 8 tons of metal can be melted, and in the smaller 3½ tons, and in the air furnace 5 tons. By means of three cranes, the large pot containing the liquid metal is transported from the cupolas to the casting pits, from whence the castings are afterwards raised, and carried to the trimming shop in the adjacent building.

In the brass-foundry there are eighteen pot fires for melting brass, the flues from which are led to the chimneys in the centre of the building. The chimneys are built on a cast-iron frame, supported on four cast-iron columns, which are let into large blocks of granite, well cramped together and bedded on a foundation of brick-work, under which there is a mass of concrete. The chimneys are held together by means of angle-irons at the four corners with connecting rods; by this arrangement the fire-brick lining is renewed as often as is required without disturbing or affecting the stability of the chimney itself.

This building is of brick, with a granite plinth, the cornice, window-sills, and string-course, being of Portland stone; the door and window frames are of cast-iron, the doors are made to slide back by running on rollers, by which they are suspended on a bar inside the building (see plate X. 5).

The roof is of corrugated galvanised iron, on a wrought-iron frame.

This building was originally intended exclusively for a brass-foundry, but in consequence of the alteration in the general design for the factory buildings, and the reduced scale upon which they have been carried out, it has been appropriated as described, but the part for the iron-foundry, though it answers very well, is not so perfect in its arrangements as a building designed expressly for the purpose would be; if, therefore, a larger establishment should hereafter be required, the whole of this building should again be appropriated as originally designed.

The estimated cost of the building was 7,800*l.*, and the total actual cost 7,746*l.* 7*s.* 8*d.*

X.—Iron Smithery. Plates XI. 1, 2, 3, 4.

This building (at M), when first erected, was intended to be only a temporary smithery for the factory, till the smitheries in connection with the factory could be built; it was, therefore, desirable that as little expense as possible should be incurred, and that all the materials employed should be again available—and as here were a number of cast-iron columns and semicircular girders in the victualling yard which had previously been used in a shed there, it occurred to me that I could design a smithery, making use of these columns, and the cast-iron window-frames of the pattern required for the permanent building, and with the simplest form of roof, which should afterwards serve as a timber-shed (see plates XI. 1, 2).

The length of the building is 110 feet, the breadth 50 feet, and the height to the tie-rods 20 feet 6 inches; the ends of the building and the spaces between the columns are of corrugated galvanised iron, the roof is also of the same material, curved so as to give a rise of only 5 feet 6 inches in 50 feet, and as this material, No. 20 gauge, is hardly thicker than card paper, it was scarcely possible to enclose so large a space with less material. The window-frames are of cast-iron, and are supported on dwarf walls half a brick thick. With the view of ascertaining which would be the best description of forges for the permanent smithery, trial was made of six according to Nasmyth's design, and six according to Hicks'; the detail of the latter is given (see plates XI. 3, 4), as after a full trial and exchanging the men from one to the other, those of this design were preferred. It will be seen by the plan that there is a window between each of the forges, and that more than half the space along the walls is occupied by windows: in consequence of the great quantity of light thus obtained, the great height and perfect ventilation, and the ample space between the forges and through the centre of the building, it has been pronounced to be one of the best workshops that ever was erected. And though erected under the circumstances described, it is probable it will always continue to be appropriated as it now is.

The total cost of this building, including the sum paid to Messrs. Nasmyth and Hicks, was 2,127*l.* 18*s.* 9*d.*

## XII.—Boat Store, Chain Cable Store, and Saw Mills.

In addition to the works already enumerated, the following buildings were erected under my superintendence, viz:—the boat-store, F, and the chain-cable store, G, from designs prepared by my predecessors in office, Captain Beatson and Sir W. Denison; and the new saw-mills, H, and eighty horse-power engine-house, I, from my own designs.

In designing the saw-mills, I was specially directed to provide for the reception of machinery for cutting crooked timber, as well as straight baulks, and for a joiner's shop over, with the machinery now used in the best conducted private establishments, for more expeditiously and economically performing all kinds of joiner's work; and to provide for fresh and salt water tanks on the top of the building, for a larger supply of water in this part of the yard, in the event of fire. It was a special object to separate the work and cost of building ships, from the work and cost of repairing them; the site of the building immediately in front of the centre building slip, and close to the eighty horse-power engine-house, was admirably adapted for carrying out these views, and the building was designed accordingly, with a basement story, into which the shafting from the engine was led; the ground floor gave ample space for the crooked timber and baulks, whilst the first floor was designed for the large joiner's shop required, over which there are two tanks, each holding 250 tons of water, one of fresh and the other of salt water, which the pumps of the eighty horse-power engine fill. The importance of having a much larger supply of water, in case of fire, was very strongly pressed by the late Rear-Admiral Sheriff, who was present at a fire in the dockyard at Sheerness, when the inadequacy of the supply there was very painfully felt, and he anticipated the same want would be found in the dockyard at Portsmouth on the event of fire there. The state of the old smitheries on the new ground, both as regards the dilapidated state of the buildings themselves, the want of light in them, and their almost suffocating state from the want of ventilation, made it necessary that these buildings should be removed and new smitheries erected; and, as I have said before, the bringing the factory on that side of the steam-basin, made it necessary to remodel the whole of the buildings on it. I was therefore ordered to prepare plans for this purpose, and the late Lieut.-Col. Irvine had other plans prepared at Somerset House, which were submitted to Mr. Fincham, the master-shipwright, to Mr. Murray, the chief engineer in charge of the factory department, and to the other officers of the yard, who, from a knowledge of the requirements of the service, were presumed to be able to give competent opinions upon the subject. The following is the master-shipwright's report upon the plans submitted to him, addressed to Lieut.-Col. Irvine.

"I have now carefully inspected the two plans furnished from your office, and have compared them with that proposed by Capt. James; and I beg to say, that I give the preference to the latter, for the following reasons. I think the lines of road are better, as the plan provides for one principal line of communication directly through the yards, an arrangement which is always of great importance where long and heavy timber is to be conveyed. The cross roads also form a better communication from the timber-sheds, smitheries, saw-mills, &c., to the different places to which the materials will have to be respectively conveyed.

"The timber sheds are likewise better disposed for stowing and selecting timber, and there is better ingress to and egress from the saw-mills and saw-pits, which are conditions of great importance. The number of saw-pits proposed in Capt. James' plan seems also essential to the duties of the yard, notwithstanding the help which may be rendered by the mills in cutting straight and curved timbers. The smithery, J, too, is more compact, and the interior may be better arranged for supervision; and it will provide great facilities for carrying on the duties of that department. Besides this, it will allow the engines to be more conveniently placed for working the pumps, fans, saw-mills, &c.

"Will you have the goodness to look through the drawings again, comparing them with reference to the points which have determined my preference? and I feel assured that you will appreciate the advantages which are indicated in the above observations.

(Signed) "J. FINCHAM."

This plan was consequently submitted to and received the approval of the Lords of the Admiralty, and I was directed to prepare the designs of the buildings in conformity to the general plan, the elevations of which were designed in character with the factory which had been built, and the engine-house and saw-mills have been built; but, in consequence of the change of officers, and the desire of the present Board of Admiralty to save the cost of the permanent brick building, which, according to my instructions, I had prepared for the smithery, this design has been set aside, and an iron structure has been ordered instead.

### XIII.—ECONOMY OF LABOUR IN THE TRANSPORT OF MATERIALS.

In 1848, a committee of revision, consisting of the following gentlemen, viz.: Sir Henry Ward, then First Secretary to the Admiralty; Capt. Milne, R.N., one of the Lords of the Admiralty; Capt. Sir Baldwin Walker, R.N., the Surveyor of the Navy; and Mr. Bromley, Secretary of the Audit Board, was appointed to visit all the dockyards at home, with the view of examining into the whole system of carrying on the duties in them, and for revising the then existing regulations respecting the receipt and issue of stores, the accounts and all other matters which would tend to introduce more regularity and economy into every department.

The heads of departments were invited by the committee to offer suggestions for improving the mode of conducting the business of the yards, and this appeared to me the most fitting opportunity for pointing out the great waste of labour, time, and money, which was incurred by the want of proper facilities for landing and transporting heavy articles or materials through the different parts of the yard. I therefore submitted for consideration designs for railroads and tram-rods through the yards, rails and travellers for landing and stacking anchors, rails and travellers for landing and stacking timber, &c. &c.

To those who are accustomed to visit large private establishments, and to see the facilities which the proprietors provide for landing and transporting heavy materials with celerity and economy, it will appear incredible that proper means for effecting the same object should not have been provided ages ago in the Government establishments.

### XIV.—RAILROADS.

In the plan for the railroads, I had to consider that the lines should be so laid out as to give the greatest facilities for communication where there would be the greatest traffic, and at the same time so to arrange the lines that a communication could be readily made with the projected branch into the dockyard, from the South-Western and South Coast Railways (which these companies, in the year 1847, were most anxious to make), to lead as straight as possible to the wharfs. The gauge, therefore, was made the same as that of the public railways, and the rails laid in such a manner as not to be above the ordinary level of the pavement of the yard, or to impede the crossing of the lines by ordinary carts.

The plan of the railroads will be seen by reference to the general plan; thus the branch from the public railroads would come through the fortification near the centre of the curtain to the right of the sluice bastion, K, and proceed straight along the south side of the basin to the wharf facing the harbour, From this line the railroad is carried round the basin and into the foundry, and factory, and other parts where required.

It is of the greatest importance that branch lines should be made into the dockyards, connecting them by this means with each other and the coal and manufacturing districts of the kingdom. The circumstances of no former war afford any precedent for the requirements of a future war. In all former wars the concentration of any considerable force by land or by sea was foreshadowed by such preparation, that the intelligence of any contemplated movement was long known before the event: but by the aid of the electric telegraph, the steamer, and the railroad, movements of fleets and armies can be made with a secresy, celerity, and precision, which no vigilance, however watchful, can give warning of, and, therefore, it behoves the Government to provide, by the same means, for the most rapid concentration of all the resources of the country, in men* and material, upon any given spot. The loss of an hour in any future war will be more seriously felt than the loss of a week at any former period. If branches were made, for example, into the dockyards of Deptford, Woolwich, and Portsmouth, the cost (even supposing the companies would not themselves now make them) considering the importance of the object to be obtained, diminished by the saving, which would be effected by doing away with part of the flotilla of victualling hoys, and dockyard lighters now employed, would not be worth consideration, if, as is possible, a positive saving would not thereby be effected. At all events, the power of combining, in the course of a few hours, the resources of several dockyards, and the country at large, would be secured; and in the event of our having to fit out a fleet with the utmost possible despatch, or to repair the disasters of war or storms, this power would be found of incalculable advantage.

The section of the railroad is given in plate XIV. 1; the gauge is four feet eight and a half inches; the rails are laid on longitudinal sleepers, which were saturated with Sir W. Burnett's solution, chloride of zinc. The cost of the line of railroad is 12*s.* 6*d.* per foot run, exclusive of the cost of the timber which was taken from the old dams. The cost of the turn-tables fixed was 109*l.*, and of the pits 26*l.*

### Tramways.

A portion of granite tramway was laid some years ago in a part of the yard principally for the purpose of facilitating the transport of masts, but as it did not extend to the shops where the masts were made, its utility was in a great

* 25,000 regular troops, independent of the garrisons, and in barracks close to the railways, is the minimum force which should at all times be ready.

measure defeated; I therefore recommended it to be extended to the shops, as has now been done. A section of the tramway is given in plate XIV. 2; the cost was 1*l.* 4*s.* 6*d.* per foot run. The wheels of the carts and trucks I designed so as to run either upon the railroad or upon the tramway or the pavement.

### XV.—Transport of Anchors.

The weight of a large anchor is about five tons. As an example of the waste of labour in the transport of anchors, let one be traced from the barge which brings it to the wharf, till it is placed in store in the old stack. A party of six or eight men proceed to the crane to land it; next a team of horses, accompanied by five men, is brought down to draw the anchor on a sledge over the rough pavement of the yard to the weigh-bridge; it is next brought back to nearly the same place where it was landed, to be "tested" by the hydraulic press; after remaining there a few days, the team of horses and men again proceed to draw it to the far end of the yard to the smithery, to undergo the "fire-proof," where, after lying about for a few days more, it is drawn back through the yard to the anchor-rack, and there, by brute force, turned up into its place. To those who know the painfully slow manner in which a dock-yard labourer and a dock-yard horse can move (it requires considerable practice to do it), the waste of money by this system will be understood, though it is difficult accurately to estimate the amount; but as the same rude method is followed in taking the anchors from the stack to the ships to which they are issued, and that between four and five hundred have to be moved annually, the cost cannot be less than 1000*l.* per annum. This system has now been done away with, in great measure, at Portsmouth, though it still exists in other dockyards.

#### Rails and Travellers for landing and stacking Anchors. Plates XV. 1, 2, 3.

I have given in plate XV. 1, 2, 3, a plan, elevation, and section of the anchor-rack, and the rails and travellers which I designed for economising the labour of transporting anchors. The traveller commands three racks for the anchors which are stacked in double rows on their crowns; each rack is 100 feet long, which gives room for 250 anchors of all sizes, which is sufficient for the current service.

These racks are placed on the Watering island, close to the test-houses, and so placed that the anchor, when landed by the crane, is commanded by the traveller, by which it can be placed at once into the rack, or, if required, can be placed on a truck or a branch of railway leading into the test-house, and weighed by passing over a weigh-bridge on its road; it is then placed again on its truck by the hydraulic crane in the test-house, and taken to the annealing furnace or fire-proof forge, which is only a few yards distant.

By this arrangement the whole labour can be done with ease and celerity by six or eight convicts. The anchors are never taken above sixty yards from the place where they are landed; and it is almost as easy to place a five-ton anchor into its place, as it is to put a walking-stick into a stand; and it is as easy to take out any one particular anchor as another; whilst, by the old method of stacking them, leaning one against another, all the outer ones must be removed to get at an inside one. The leading man who superintended the stacking and transport of the anchors, stated, that to move one of the inside anchors, he would require four horses and four men to assist him, and that it would take three days to get it to the water's edge. The cost, therefore, would be 3*l.* 13*s.* 6*d.*; whilst, by the plan I have introduced, any anchor that may be required can be put into a barge in less than half an hour, and at a cost, if convicts are employed, of less than sixpence. Nine-tenths of the cost of moving anchors will be saved by this arrangement; and if the same system is carried out in the other dockyards, the saving under this head alone will be very considerable. The dimensions of the racks, travellers, and rails, are given in the plates. The cost of the rails and traveller, exclusive of the cost of the timber, which was taken from the old dams, was 450*l.*

### XVI.—Landing, stacking, and transport of Timber.

To understand the advantage of the mode I have introduced for landing and stacking timber, it will be desirable to describe the method followed up to the time of its introduction, in the same manner that I have described the old method of moving the anchors.

A timber ship arriving with a cargo for her Majesty's dockyard, is anchored opposite the Common Hard, at a considerable distance from the place of landing. There, as the baulks are launched out from the bow-ports of the ship, they are formed into rafts, several men being in attendance to perform this duty, and waiting for the tide to float the rafts up to the landing-place. At the landing place several teams of horses and gangs of workmen are then employed in drawing up the baulks to some open space for inspection, where, after having been laid out for measurement and inspection for some days, teams of horses and parties of men are again employed to draw the baulks over the stones to some, generally out of the way, inconvenient place, where, by means of a "pry-pole," they are piled up in stacks.

The cost of landing and stacking timber in this way in this one dockyard, in the years 1847-8, was 1682*l.*; and as the same process is followed in taking the timber from the stacks to where it may be required, as at the saw-mills, saw-pits, &c., the further cost of transport cannot be less than one-third of the above sum—making a total of at least 2250*l.* per annum. The same process is followed in the other dockyards; and the expenditure under the one head cannot be less than 10,000*l.* per annum.

### Rails and Travellers for landing and Stacking Timber.

I submitted to the committee, therefore, plans for two parallel elevated rails and travellers (see plate XV. 1, 2, 3), like those for moving the anchors, to be put up on the Battery-ground; being perfectly persuaded that at least three-fourths of the expenditure under this head would be thereby saved, and I was in consequence ordered to put up one. The double rail is 800 feet long; the distance between the rails which is spanned by the traveller being forty-five feet; this enables the traveller to stow two parallel rows of timber the whole length; and as the rails project over the wharf, so that the traveller can pick up the timber either from the water or barges, and the whole labour can be done by a gang of convicts, it is obvious that I understate the saving that can be made, when I say it will not be more than one-fourth of the cost of the old system.

The timber ships not drawing more than 13ft. 6in. can lie afloat at this spot even at low water at spring tides; so that each baulk, as it is launched out of the bow-port, can be immediately picked up by the traveller, laid down for inspection and again picked up for stacking; and as a branch of the railroad passes under the rails, the baulks can be readily placed on a truck and drawn round by the convicts to the saw-mills, or wherever required.

I recommended that two parallel rails should be put up, but I was ordered to put up one only (at L); and by the trial that has already been made, employing ordinary free labourers for the work, one-third of the cost of landing and stacking timber has been saved; but to reap the full benefit of this plan, it must be carried out to such an extent, as will enable all the timber to be landed in a similar manner; and as this is a duty peculiarly suited for convicts, who may have tasks set them, and it is at the very door of their barracks, the whole of this labour should be performed by them. The cost of the rails and travellers which have been put up, exclusive of the cost of the timber, which was taken from the old piles used in the dams, was 750*l.*; but even if the cost of the timber was added to this, it is obvious that the outlay, in the first instance, would be very trifling when compared with the annual saving to be effected. The plan should, therefore, be adopted in all our dockyards. A glance along the wharfs of the Thames shows that no private merchant would hesitate a moment about it.

### XVII.—Landing and Storeage of Coals.

In constructing Frederick's Battery, I pressed upon the attention of the Lords of the Admiralty the importance of availing themselves of the space under the terreplain for the guns, by converting it into arched stores for the coals required for the dockyard. I was urged to propose this from a knowledge of the great want of proper coal stores in the yard, and the great waste of money incurred in receiving the coals, and the damage and waste done to the coals by the system in practice.

In receiving the coals, it was whipped from the collier into carts, and horses employed first to draw it to the weighbridge, which is at a considerable distance from the wharf, and from thence either to the underground arches, were it was thrown down twenty feet, or taken to open places temporarily prepared for it, where it had to be piled up nearly twenty feet high; in the one case requiring a great amount of labour and unnecessary cost in getting the coals up again from the subterranean stores, whilst the temporary stores occupied spaces which interfered with the labour of the yard.

The quantity of coals received at the dockyard in the year 1847, was 15,000 tons, of which 6000 was for the dockyard, and 9000 for steamers; the cost per ton of receiving and delivering the coal for use is 1*s.* per ton, which gives a cost of 750*l.* for the year. By the present arrangement a short piece of railroad is run from the wharf at the end of Frederick's Battery to the stores under it, which are twenty in number, and will each hold 150 tons, giving storeage for 3000 tons, which, considering that the coals are not all delivered at the same time, will be found sufficient for the service of the yard, and steamers fitting out; and it is to be hoped the more effectual means which I have submitted to the Admiralty for coaling the steamers will make it unnecessary to receive any considerable quantity of coals at the dockyard for the use of steamers coaling at the port. A weigh-bridge is placed on the line of rail, so that the coal is weighed, either on receipt or delivery, in passing over it; and as the whole of this labour may be done by the convicts, a considerable economy in this branch of work will thus be also effected.

## XVIII.—Coaling of Steamers.

Whilst the Government has with a proper foresight very wisely provided an efficient factory, with a basin and docks, for expeditiously repairing our steam vessels, the want of proper means for expeditiously coaling them is a cause of delay, which, in the event of war, will very seriously detract from their efficiency; and the time may come, as has been said by a distinguished naval officer, "when the safety of England may depend on the celerity with which our steamers can be coaled."

This is, therefore, a most important question. The supply of coals at Portsmouth and Plymouth is at present received from Newcastle or South Wales, and is brought round the Land's-end or through the Straits of Dover in colliers; it is obvious, therefore, that no reliance can be placed on our receiving a regular supply brought in this manner during a time of war, and that the coals must be brought by railway.

I therefore submitted to the Lords of the Admiralty a design for a jetty at D (see general plan, plate I.), connected with the South-Western Railway, where it enters the Royal Victualling yard at Gosport, with a store at E for such a supply as it might be thought necessary to keep, which I estimated at 10,000 tons, which would be sufficient for about twenty steamers. The advantage to be derived from this arrangement I enumerated as follows.

1st. That it provided for the supply being received as at present by colliers at the most convenient spot in the harbour for them to discharge their cargoes at, or for the steamers to receive their coals from. Their lordships were pleased to order a committee of officers to inspect and report upon the proposed site for the jetty; and they confirmed by their report the superiority of the site over any other in the harbour.

2ndly. That in the event of war the arrangement would be already made for receiving the coals by railroad direct from the collieries, and when, if the subject was merely viewed in its economic bearing, the coals could be delivered at a very much less cost than they could then be brought by sea.

3rdly. That gas and water pipes could be brought to the end of the pier, and that the steamers could receive their water and provisions from the Victualling yard at the same time that they received their coals, and this as well at night as by day,—and thus, that the cost as well as delay of taking provisions to the steamers in hoys or barges would be saved.

4thly. That the steam-power and the people required to work the engines for coaling would have constant employment, as the engine could be so placed as to be able to work the pump in the Victualling yard, for doing which horses are now hired, and for sawing barrel staves and other work now done by manual labour in that department.

5thly. That the officers in charge of the Victualling yard could also take charge of the coal depot, issuing and receiving coals like any other stores under their charge.

6thly. That as compared with the proposed plans for floating depots it was the most economical, and that it would meet all the requirements of the service.

The late Lord Auckland, the First Lord, and Sir Henry Ward, the Secretary to the Admiralty, and Lieutenant-Colonel Irvine, the Director of Works, fully approved of the proposed plan, and intended to carry it out.

In the meantime a seventy-four gun ship, the "Malabar," has been converted into a coal hulk, with a steam engine and machinery in her, for hoisting in and out the coals, but the disadvantage of this arrangement, and its inadequacy for the wants of the service has been strongly felt.

1st. Because the steamers cannot be coaled sufficiently expeditiously from her.

2ndly. Because she holds only sufficient coals for three large steamers, which is quite inadequate to the wants of the service, so that when the colliers arrive in any numbers together she is soon filled, and her machinery and men are idle whilst the colliers are discharging their cargoes on the wharves of the dock-yard, or into other hulks.

3rdly. Because the coals are much injured by being thrown down into the lower hold of such a large ship.

4thly. Because taking the value of the ship, which is built of teak and perfectly sound, she has been more expensive, than the more complete permanent work I proposed, and

5thly. Because there is not sufficient work for the engine and people on board her, and, consequently, the system is unnecessarily expensive in its working.

6thly. That this large ship occupies a space in the harbour which even now is found to be very inconvenient, but would be found to be most seriously so in the event of war.

There are many situations in which coal depots will be required, where we can only have floating depots; and, consequently, it is to be hoped that the system of coaling from the "Malabar" will be made as perfect as it can be from a ship, that it may be adopted for all the floating depots that may hereafter be required, but for the reasons which have been enumerated there are radical defects in floating depots which make them quite unsuited for such a station as Portsmouth.

The "Avenger" steamer carried 550 tons of coal, and, when steaming, burned thirty-six tons per diem; her store therefore would last fifteen days; now if we assume that such a steamer was stationed in the Channel during a time of war, with her steam constantly up, and that she expended thirty tons per diem, and that her store would last eighteen days, and that by one system of coaling it took three days, and by another half a day every eighteen days to renew her stock, it is obvious in one case that one out of every seven steamers in the Channel would be constantly coaling, whilst in the other, one out of every thirty-seven would be so occupied; and, therefore, any plan by which the operation of coaling can be expedited is virtually equivalent to an addition to the numerical force of the steam navy: for assuming that thirty-seven steamers were stationed in the Channel, in the one case five, and in the other one only, would be always coaling; that is, we should have thirty-six instead of thirty-two steamers always efficient—or, the entire cost of providing and maintaining four steamers might be saved to the country. But the absence of a steamer from her station at a critical period may be attended with consequences of much greater importance than any consideration of mere cost; there is no port, or town, or single point upon the coast which in the absence of an efficient guard would not be liable to attacks from an enemy's steamers; and, therefore, it behoves us to make arrangements for giving the utmost possible efficiency to our steam power, which we cannot be said to have done, as long as the present inefficient system of coaling exists. We must provide for receiving the coals by railway, and we must provide for our steamers receiving their coals, provisions, and water, in a few hours, either by night or by day. I feel it is the duty of every one to press upon the Government the importance of so doing. I have supplied the plans by which I have shown it can be done, and feel perfectly certain that the arrangements I have proposed will be found the least expensive in time of peace, as they will be found imperatively necessary in time of war.

### XIX.—Cost of Works Executed.

The total expenditure upon the great works executed under my direction in the dockyard, on the *barracks and batteries for the Royal Marines, in the Victualling yard, in the hospital, and on the breakwater at Haslam, was 732,239*l*. The cost of superintendence was 11,500*l*. for the four years, or one and a-half per cent. upon the expenditure; the usual charge for designing and superintending such works by private engineers is seven and a-half per cent., or five times more.

In the report upon the works which had been executed under my superintendence at Portsmouth, which I forwarded at the time I resigned my appointment, I stated, and have now great pleasure in repeating, that "I should neither do justice to my own feelings, nor the merits of those who have served under me during the execution of these works, if I were to omit to state the great assistance I have received from them, and more particularly from Mr. Wood, the clerk of works in the dockyard."

I think myself fortunate in having been selected for the arduous duty entrusted to me; and although in my anxious desire to complete what I had begun, I was induced to refuse two more lucrative appointments than the one I held under the Admiralty, and, consequently, made pecuniary sacrifices which, in a worldly point of view, I was hardly justified in doing; still I look back with pleasure to the time I was employed in the service of the Admiralty, and to the many kind friends it was the means of introducing me to; and I take this opportunity of tendering my grateful thanks to Rear-Admiral Hyde Parker, C.B., and to Rear-Admiral Prescott, C.B., the superintendents of the dockyard, for the many marks of personal kindness, and the support I uniformly received from them in the execution of my duties.

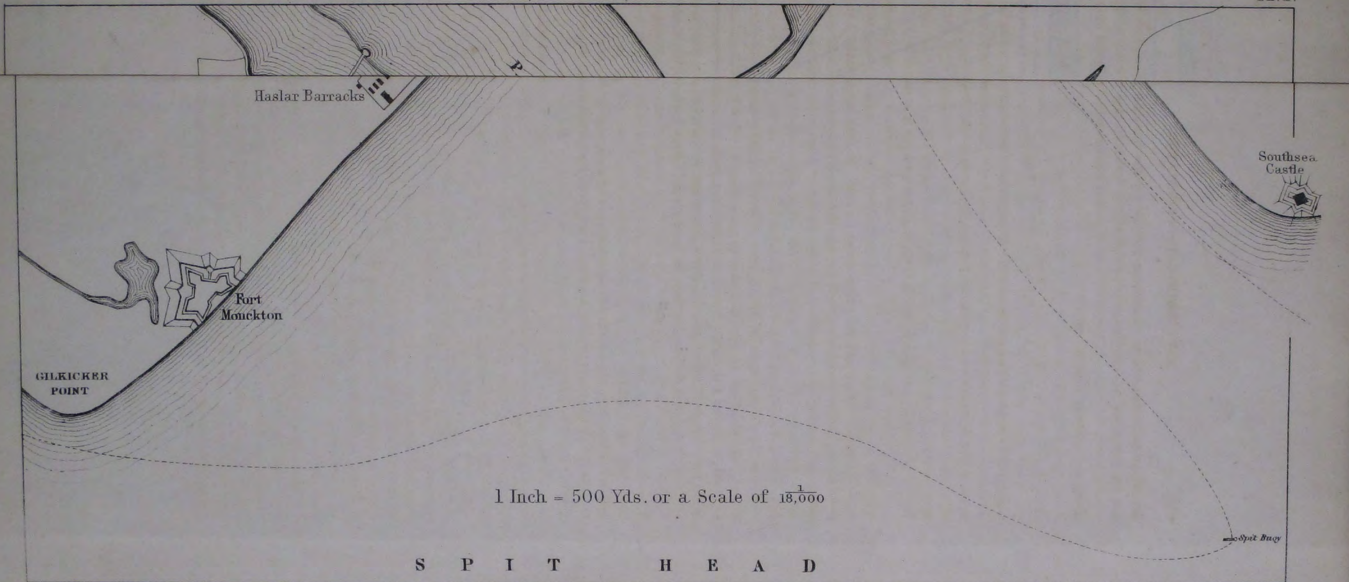
H. JAMES,
Captain R.E.

*Sept.* 29, 1851.

* Described in vol. ii., new series, of the Corps Papers.

# GENERAL PLAN OF PORTSMOUTH.

PL. 1.




J. R. Jobbins

# PAPER IV.

## On the Relative Value of Specimens of Native Gold from the different Countries whence it is brought to Market in these Colonies, communicated to the Royal Society of Van Diemen's Land. By His Excellency Sir W. T. Denison, R.E., F.R.S. [*Read 22nd March*, 1852.]

The circumstances in which these colonies are now placed give a special interest to communications which may in any way tend to elucidate the structure and combinations of the metals generally, more especially of that precious metal, the discovery of which on the Main-land of Australia has been productive of such serious effects upon the inhabitants of Van Diemen's Land.

The extent to which Gold is daily bought and sold renders it very desirable to establish, within as narrow limits as possible, the value of a commodity whose intrinsic worth, great in itself, is very liable to deterioration by admixture with foreign bodies.

I propose in this communication to bring before the Society the results of a series of experiments which I have lately made, the object of which has been to establish, as far as possible, some simple mode of determining the relative value of the native Gold from the different countries whence it is brought to market; and, secondly, after having established this point in a satisfactory manner, to point out also a simple mode of determining the value of mixed specimens or samples of Gold, such as are brought to market, containing generally some portions of quartz, or other extraneous material, mixed with the Gold, but not chemically combined with it.

I do not bring these experiments before the Society as in any respect perfect, but merely as indicating a course of investigation which may be pursued with advantage; and I trust that others will not only follow up the course herein marked out, but will turn their attention to the chemical analysis of the materials found in connection with Gold, for by this only can positive and definite results be obtained; although by the mode in which I have worked, the deductions are sufficiently accurate to serve as a guide to persons engaged in the purchase and sale of Gold, as a matter of mercantile speculation.

The first object to which I turned my attention was the establishment, if possible, of the average value of the pure native Gold from the different fields,— and when I use the term *pure*, I mean only that the specimens were free from any admixture of extraneous matter, as quartz, &c. It is evident that if, by a well-conducted series of experiments, it could be proved that the Gold from any given locality was chemically combined in some fixed proportion with some other metal, while that from another locality was alloyed, not only in different proportions, but perhaps with a different metal, keeping yet its own combination uniform and regular, within certain narrow limits, much would be done to establish the mercantile value of the Gold from each of these districts. Again, should the result of the experiments go to prove that the quality of the Gold varied very much in the same district, it would be of use, inasmuch as it would prove the necessity of a special investigation into the quality of each sample.

I think that the experiments which I have made are sufficient to prove, at all events with regard to the Mount Alexander diggings, such a uniformity of structure as is quite sufficient to form the basis of some calculations which will very much facilitate the operations of those who are engaged in the sale or purchase of Gold; but to this I shall allude more specifically hereafter. Before I enter into the detail of these experiments, it may be desirable that I should give some brief explanation of the different forms under which the Gold generally presents itself. Gold is found in all cases in a metallic form, or, as it is called, native Gold. In this state, however, it is by no means pure, being generally combined chemically with some other metals, as platina, silver, copper, &c.

In many instances it is brought to market in lumps, or "nuggets" as they are called, which contain, besides the Gold alloyed with some metal, portions of quartz or other extraneous material, forming the matrix in which the Gold was originally deposited, or with which it had become combined accidentally. In other cases it is brought to market in dust, or grains of a greater or less degree of fineness, the product of the washing of the earthy strata in which the Gold had been deposited, this dust of course containing more or less extraneous matter, in proportion to the care with which the washing had been conducted, and consisting very commonly of iron ore, sand, earth, particles of quartz, &c.

The object of the experiments which I am now about to lay before the Society was to discover the quantity of the alloy combined with the native Gold, in the first place; and, having established this, to ascertain the amount of the extraneous matter either in the lumps or the dust. Should I be able to show that this can be done with facility, I shall have done something towards establishing a standard by which the dealers in Gold may regulate their transactions.

Now, every material whose structure is definite has a given specific gravity; that is, a given bulk of such material will weigh a certain number of ounces or grains. The standard of comparison in all cases is water: a cubic foot of distilled water, at a temperature of 60° of Fahrenheit, the barometer standing at 30 inches, will weigh 1000 ounces; and this is taken as the specific gravity of water. Tables of specific gravities are given for a variety of other substances, and these tabular values are, in point of fact, the actual weights of a cubic foot of each: for instance, the specific gravity of pure Gold cast is 19258; of pure Gold hammered, or laminated, 19361. In point of fact, these numbers represent in each case the weight in ounces of a cubic foot of this material; the greater weight of the hammered Gold being due, as may be easily imagined, to the compression of the particles, a greater number having been crowded into the same space.

Gold, with the exception of platina, is the heaviest metal with which we are acquainted: any admixture or alloy of the Gold with other metals will diminish its specific gravity, and, as a matter of course, its value in some proportion to the quantity, weight, and value of the metal with which it is combined;—for instance Standard Gold, as it is called, that is, the Gold of which the circulating medium in England is composed, contains 2 parts of copper in 24; and the admixture of this proportion of copper, a metal whose specific gravity is 8878, reduces the specific gravity of Standard Gold to 17486, if cast; and to 17589, if hammered, or laminated, as it is when in coin.

These are facts which have been carefully examined and recorded, and they afford the principal elements which are required in discussing the subject, affording a standard of comparison not only as regards the specific gravity of metallic compounds, but as regards the exchangeable value of the precious metal.

In carrying out a series of experiments as to the specific gravities of various metallic compounds, my first object was to ascertain the degree of confidence which I could place on a delicate apparatus which I have used on several occasions for the purpose of ascertaining the specific gravities of bodies. A careful comparison was first made of the various weights employed, and an experiment of the amount of accuracy with which the specific gravity of a known material could be determined gave me every reason to be satisfied with the character and condition of the balance. The following detail will enable the Society to judge how far this confidence was well founded. The standard value of Gold is £3 17*s.* 10½*d.* per ounce, and according to this a sovereign should weigh 123·27 grains, and its specific gravity should be, as before stated, 17589.

Every day's circulation, however, must diminish the weight of a sovereign, though it does not affect its specific gravity. A sovereign, not of a very old date, being placed in the scale, its weight was found to be 123·12 grains, showing a loss of ·15 of a grain, while its specific gravity appeared to be 17588, a difference from the standard specific gravity of too trifling an amount to merit notice. Having thus shown that confidence might be placed in the instruments employed, I will explain the mode in which the experiments were conducted.

The specimens were first weighed very carefully, the balance being delicate enough to turn with a very small fraction of a grain when loaded with upwards of 2 ounces. The smallest weight employed was the $\frac{1}{16}$ of a grain. The weight being noted, the specimen was then suspended by a fine hair to a hook on the underside of the scale in a glass of distilled water, care being taken to free it from any bubbles of air which might perhaps exist in cavities on the metal, or adhere to its surface. Allowance was made for the hair used in suspending the specimen, and the weight with the necessary deductions was recorded. The difference between the weight in air and the weight in water is in point of fact the weight of a quantity of water equal in bulk to the specimen, and a simple proportion will thus give the specific gravity, or the weight of a cubic foot of the material experimented on, as follows:—As the difference between the two weights is to the weight of a cubic foot of water, or 1000, so is the weight of the specimen in air to its specific gravity; or, more shortly, if W be the weight of the specimen in air, $w$ that in water, G the specific gravity $G = \frac{W}{W - w} \times 1000.$

Where the specimen consisted of dust, a small silver scale was suspended by fine hairs to the under part of the principal scale, and exactly balanced when in the water by weights, the amount of which was recorded. The dust was then placed in the scale, and when the whole was accurately balanced, the sum of the weights in the opposite scale, less the recorded weight of the scale itself, gave the weight in water of the dust.

The first experiments were made on coin :—

| | Grains. |
|---|---|
| No 1, a sovereign weighed in air . . . . . . | 123·12 |
| " " " in water . . . . . . | 116·12 |
| Difference . . | 7· |

Thus $\frac{123 \cdot 12}{7 \cdot} \times 1000 = 17588$ specific gravity.

17589 tabular specific gravity.

1 difference.

| | Grains. |
|---|---|
| No 2, a Napoleon weighed in air . . . . . . | 99·5 |
| " " " in water . . . . . | 93·75 |
| Difference . . . | 5·75 |

$\frac{99 \cdot 5}{5 \cdot 75} \times 1000 = 17304$ specific gravity.

French standard Gold is said to contain $\frac{1}{10}$ of Copper, in which case its specific gravity would be 17316 : the difference between this and the specific gravity, as determined by experiment, is very trifling.

3. An American gold coin of the value of 50 dollars from the Californian Mint—

| | Grains. |
|---|---|
| Weighed in air . . . . . | 1310 |
| Weighed in water . . . . . | 1235 |
| Difference . . . . | 75 |

$\frac{1310}{75} \times 1000 = 17466$ specific gravity.

4. An American gold coin of the value of 20 dollars from the United States Mint—

| | Grains. |
|---|---|
| Weighed in air . . . . . | 515·75 |
| Weighed in water . . . . . | 486·20 |
| Difference . . . . | 29·55 |

$\frac{515 \cdot 7}{29 \cdot 55} \times 1000 = 17453 \cdot 5$

On reference to Table No. I, showing the value of alloys of Gold with Silver, it will be seen that these American coins are not worth more than 10*l.* 5*s.* 3*d.* and 4*l.* 0*s.* 8½*d.* respectively at the mint price of Gold and Silver; and therefore in these colonies, where deduction must be made for freight, insurance, and other charges incidental to the transmission of these coins as bullion, their market value will be very much reduced : indeed, they appear to be inferior in value to the ordinary California Gold, if we may judge from the sample, an analysis of which is given further on in the proportion of 75*s.* 3*d.* to 77*s.* 2*d.* per ounce. If these coins are to be taken as the representatives of a given number of dollars, the value of that coin in sterling money would appear to be 4*s.* 1½*d.* and 4*s.* 0¼*d.* The specific gravities of these two coins approximate very nearly to each other, but their actual value depends upon the character of the metal with which the Gold is alloyed. This is a matter of importance, and the more so as an impression may very probably exist that the more valuable the metal combined with the gold the more valuable the compound will be; whereas the reverse is the case.

I have shown before that the specific gravity of pure Gold which, when cast, is 19258, and when hammered 19361, is reduced to 17486 in the one case, and to 17589 in the other, by an admixture of one-twelfth part of Copper at a specific gravity of 8878. Now the value of Copper in the state of coin as compared with Gold may be taken at $\frac{1}{1000}$; and as the value of 480 grains of Standard Gold, consisting of 440 grains of pure Gold and 40 of Copper, is 77*s.* 10·5*d.* the Gold in the compound is worth 77*s.* 10·42*d.*, while the Copper is not worth more than ·08 of a penny. Pure Gold may then be taken to be worth 2·1237*d.* per grain, and in all the calculations into which the value of Gold enters this will be used as representing it.

When, however, Gold is alloyed with any other metal, of course a separate calculation will be required; and as the Gold of California and Australia is combined very generally with Silver, it will be desirable to determine the amount of that metal which, when mixed with pure Gold, will bring down the specific gravity to that of the standard, viz., 17486. The specific gravity of Silver is given in the Tables as 10474; and the following formula will, when the proper substitutions are made, give the amount of Silver contained in any specimen of mixed Silver and Gold whose specific gravity is known. Let $x$ be put for the weight of Silver in the compound, S the specific gravity of Gold $= 19258$, $s$ the specific gravity of Silver $= 10474$, $f$ the specific gravity of the compound in this case 17486, $c$ the weight of the compound, or 480 grains—

$x = \frac{(S-f)\,s}{(S-s)\,f}c$ . . $x$ in this case will be equal to 58 grains; there will therefore be 422 grains of Gold and 58 grains of Silver in a specimen of mixed Silver and Gold weighing 480 grains, and whose specific gravity is 17486. In this case the Silver is pure; and in order to decide as to the market value of this ingredient, it will be necessary to ascertain the amount of alloy by which pure Silver is reduced to standard, the value of which, at the established ratio which it bears to Gold, namely, 1 to $15\frac{13}{62}$, is 60·78*d.*, or about $60\frac{3}{4}$*d.* per ounce. The proportion of Copper which is introduced in order to lower pure Silver to standard is $\frac{3}{40}$; that is, 37 parts of pure Silver and 3 of Copper make 40 parts of Standard Silver: the value of this compound is, as we have seen, 60·78*d.* per ounce, of which 444 grains consist of pure Silver, and 36 of Copper. The value of the Copper is $36 \times {\cdot}002 = {\cdot}072$. The value of the Silver is equal to

$\frac{60{\cdot}78d. - {\cdot}072}{444} = \frac{60{\cdot}708d.}{444} = 0{\cdot}13678$ of a penny per grain.

As there are 58 grains of pure Silver and 422 grains of pure Gold in an ounce of the mixed metal, whose specific gravity is 17486, the actual value of the compound will be—

| Grains. | *s.* | *d.* |
|---|---|---|
| 422 at 2·1237 = | 74 | 8·2 |
| 58 at ·1367 = | | 7·93 |
| | 75 | 4·13 |
| And as the value of the same quantity of Standard Gold alloyed with Copper is . . . | 77 | 10·5 |
| The difference, or . . | *s*2 | 6·37 |

is the measure of the inferiority of the value of this alloy of silver as compared with that of Copper in the Standard Gold coin of England.

This result is easily explained, for it is evident that the lighter the material combined with the Gold, the less amount will be required to reduce its specific gravity, and, therefore, that the compound will contain more of the most valuable metal, and less of the inferior.

Silver, with the exception of platina, is the heaviest of the metals usually found in combination with Gold; and as the value of platina is equal, if not superior, to that of Gold, it is not of importance, in a mercantile point of view, to attempt to determine a matter which can have little or no effect upon the market price of a commodity. I have therefore assumed that Silver is the alloy generally found with the native Gold both of California and these colonies. It is known to be the case as regards California; and in taking it for granted here, any calculations which I may make will err in defect rather than in excess.

The following experiments were made for the purpose of determining the specific gravity of different specimens of Gold completely free from extraneous matters :—

5. A specimen of California Gold, apparently crystallised—

| | Grains. |
|---|---|
| Weighed in air . . . . | 28·5 |
| Weighed in water . . . | 26·85 |
| Difference . . . | 1·65 |

$\frac{28\cdot5}{1\cdot65} \times 1000 = 17272$ specific gravity.

6. A specimen of California Gold containing a quantity of Quartz—

| | Grains. |
|---|---|
| Weighed in air . . . . | 279·87 |
| Weighed in water . . . . | 260·25 |
| Difference . . . | 19·62 |

$\frac{279\cdot87}{19\cdot62} \times 1000 = 14264$ specific gravity.

This Gold was fused into a button—

| | Grains. |
|---|---|
| Weighed in air . . . . | 257·68 |
| Weighed in water . . . . | 243·06 |
| Difference . . | 14·62 |

$\frac{257\cdot68}{14\cdot62} \times 1000 = 17625$ specific gravity.

7. Specimen of gold from Mount Alexander, apparently pure—

| | Grains. |
|---|---|
| Weighed in air . . . . | 16·0 |
| Weighed in water . . . | 15·12 |
| Difference . . . | ·88 |

$\frac{16\cdot0}{\cdot88} \times 1000 = 18181$ specific gravity.

8. Specimen from Mount Alexander—

| | Grains. |
|---|---|
| Weighed in air . . . . | 64·80 |
| Weighed in water . . . . | 61·25 |
| Difference . . . | 3·55 |

$\frac{64\cdot80}{3\cdot55} \times 1000 = 18253$ specific gravity.

9. Specimen from Mount Alexander—

| | Grains. |
|---|---|
| Weighed in air . . . . | 228·80 |
| Weighed in water . . . | 216·25 |
| Difference . . . | 12·55 |

$$\frac{228{\cdot}80}{12{\cdot}55} \times 1000 = 18231 \text{ specific gravity.}$$

10. Same specimen—

| | Grains. |
|---|---|
| Weighed a second time in air . | 228·32 |
| Weighed a second time in water . | 215·75 |
| Difference . . . | 12·57 |

$$\frac{228{\cdot}32}{12{\cdot}57} \times 1000 = 18164 \text{ specific gravity.}$$

11. A specimen of Gold cast from some clean-looking nuggets from Mount Alexander—

| | Grains. |
|---|---|
| Weighed in air . . . . . | 231·75 |
| Weighed in water . . . . . | 219.00 |
| Difference . . . | 12·75 |

$$\frac{231{\cdot}75}{12{\cdot}75} \times 1000 = 18176 \text{ specific gravity.}$$

12. Five specimens which were experimented on separately, and the details of which will be given hereafter, were fused into a button. In their original state they weighed 365·1 grains; when the button came out of the crucible with the slag adhering to it the weight was 365·185, this increase of ·085 being due probably to the borax used as flux. The slag was removed, and the specimen then

| | Grains. |
|---|---|
| Weighed in air . . . . . | 361·625 |
| Weighed in water . . . . . | 342·27 |
| Difference . . . | 19·355 |

$$\frac{361{\cdot}625}{19{\cdot}355} = 18688 \text{ specific gravity.}$$

13. Gold from Mount Alexander cast and then hammered,

| | Grains. |
|---|---|
| Weighed in air . . . . | 238·28 |
| Weighed in water . . . . | 225·54 |
| Difference . . . | 12·74 |

$$\frac{238{\cdot}28}{12{\cdot}74} \times 1000 = 18703 \text{ specific gravity.}$$

If then this be reduced in the proportion of 17486 : 17589, its specific gravity previous to being hammered would be 18703—103 = 18600.

14. A quantity of Gold-dust, apparently very clean, and weighing 962 grains, was carefully examined, and iron-sand and quartz to the amount of 1·57 grains removed; the whole was then carefully experimented on, and the specific

gravity determined: the Gold was then fused into a button, and the specific gravity again determined.

| | Grains. |
|---|---|
| Original weight . . . . . . . | 962 |
| Iron-sand and quartz removed . . . | 1·57 |
| Weight of Gold apparently pure . . | 960·43 |
| Weight when cast into a button and cleaned of the slag . . . . . . . | 955·00 |
| Loss in melting . . . | 5·43 |
| Weight in air . . . . | 955·00 |
| Weight in water . . . . | 903·13 |
| Difference . . . | 51·87 |

$$\frac{955{\cdot}00}{51{\cdot}87} \times 1000 = 18411{\cdot}4 \text{ specific gravity.}$$

It may fairly be assumed from these experiments that the specific gravity of the Gold from Mount Alexander ranges from 18176 to 18703, and, therefore, that in its pure state, unmixed with any extraneous matter, its value exceeds that of Standard Gold; while, as far as can be judged from the few experiments which I have been able to make, as well as from the returns which have been furnished to me of the actual chemical analysis of certain specimens, the Gold from California will range in its specific gravity from 17272 to 17809. I have not data at present to determine the matter more closely. The following Table has been computed in order to enable any person to ascertain at once the amount of Gold and Silver contained in an ounce of mixed metal of various specific gravities ranging from 18500 down to 17100, and at the same time the actual value of the compound at the rates before stated. The range of the Table is limited, but it is hardly probable that any native Gold will fall below 17100, or exceed materially 18500. It would, however, should such a case occur, be easy to extend the Table, for it is evident from an inspection of the column of differences, that there is a steady law of progression, the differences being nearly constant.

TABLE.

| Specific Gravity of Sample. | Total Weight. | Weight of Pure Gold. | Weight of Pure Silver. | Value of Gold at 77*s.* 10·42*d.* | Value of Silver at 65·65. | Value per Ounce of Mixed Metal. | Difference. |
|---|---|---|---|---|---|---|---|
| | | | | | | *s.* *d.* | |
| 18500 | 480 | 456·55 | 23·45 | 80 9·58 | 3·20 | 81 0·78 | |
| | | | | | | | 12·99 |
| 18300 | | 450·05 | 29·95 | 79 7·77 | 4·09 | 79 11·79 | |
| | | | | | | | 14·01 |
| 18100 | | 443·38 | 36·62 | 78 5·6 | 5·00 | 78 10·6 | |
| | | | | | | | 13·5 |
| 17900 | | 436·58 | 43·42 | 77 3·17 | 5·93 | 77 9·10 | |
| | | | | | | | 13·86 |
| 17700 | | 429·61 | 50·39 | 76 0·36 | 6·88 | 76 7·24 | |
| | | | | | | | 14·12 |
| 17500 | | 422·5 | 57·5 | 74 9·26 | 7·86 | 75 5·12 | |
| | | | | | | | 15·45 |
| 17300 | | 415·22 | 64·78 | 73 5·8 | 8·85 | 74 2·65 | |
| | | | | | | | 14·80 |
| 17100 | | 407·77 | 72·23 | 72 1·98 | 9·87 | 72 11·85 | |

Having thus arrived at the value of specimens of Gold alloyed with Silver, but unmixed with any earthy or stony particles, upon the supposition that the specific gravity of such specimens can be obtained to a moderate degree of accuracy, the next step is to determine the amount of extraneous matter in specimens containing evidently masses of quartz, or other analogous material, and the reduction in value consequent upon such an admixture.

In order to arrive at a reasonable amount of accuracy in such a calculation, it will be necessary to assume an average specific gravity as that of the unmixed native Gold of any given district :—

| | Sp. Gr. |
|---|---|
| No. 7 | 18181 |
| „ 8 | 18253 |
| „ 9 | 18231 |
| „ 10 | 18164 |
| „ 11 | 18176 |
| „ 12 | 18688 |
| „ 13 | 18606 |
| „ 14 | 18411 |
| 8) | 146710 |
| | 18338·75 mean specific gravity. |

For instance, from the above experiments, it may be assumed that the average specific gravity of Mount Alexander Gold is 18338·75, or say 18300. If, then, this be taken as the starting point, it will be easy to calculate the reduction in the specific gravity caused by the presence of extraneous matter, on the supposition that the specific gravity of such matter be known. Now, as a general rule, this matter may be taken to be quartz, or some material nearly allied to it. Clay and sand can be removed by washing, and need not, therefore, be noticed. The stony particles imbedded in the Gold are of such a character as to differ little from quartz in weight. The following experiments were made in order to determine the average specific gravity of auriferous quartz :—

15. Quartz from the Turon—

| | Grains. |
|---|---|
| Weighed in air . . . . | 535·5 |
| Weighed in water . . . . | 330·15 |
| Difference . . . | 205·35 |

$$\frac{535{\cdot}5}{205{\cdot}35} \times 1000 = 2607 \text{ specific gravity.}$$

16. Veined Quartz, with a trace of Gold from Mount Alexander—

| | Grains. |
|---|---|
| Weighed in air . . . . | 639·5 |
| Weighed in water . . . . | 396·5 |
| Difference . . . | 243·0 |

$$\frac{639{\cdot}5}{243{\cdot}0} \times 1000 = 2631 \text{ specific gravity.}$$

17. Veined Quartz from the spurs of Ben Lomond, near Fingal—

| | Grains. |
|---|---|
| Weighed in air . . . . | 234·75 |
| Weighed in water . . . . | 145·25 |
| Difference . . . | 89·50 |

$$\frac{234{\cdot}75}{89{\cdot}50} \times 1000 = 2623 \text{ specific gravity.}$$

18. Quartz from Fingal—

| | Grains. |
|---|---|
| Weighed in air . . . . | 1201 |
| Weighed in water . . . | 740·75 |
| Difference . . . | 460·25 |

$$\frac{1201}{460{\cdot}25} \times 1000 = 2606{\cdot}6 \text{ specific gravity.}$$

19. Second specimen of same—

| | Grains. |
|---|---|
| Weighed in air . . . . | 899 |
| Weighed in water . . . . | 556·5 |
| Difference . . . | 342·5 |

$$\frac{899}{342{\cdot}5} \times 1000 = 2624{\cdot}6 \text{ specific gravity.}$$

20. Third specimen—

| | Grains. |
|---|---|
| Weighed in air . . . . | 284·25 |
| Weighed in water . . . . | 175·5 |
| Difference . . . | 108·75 |

$$\frac{284{\cdot}25}{108{\cdot}75} \times 1000 = 2614{\cdot}7$$

There is but a trifling difference in the result of these experiments; the mean of the different specific gravities may therefore safely be taken as the standard specific gravity of Gold-bearing quartz.

| | Sp. Gr. |
|---|---|
| No. 15. | 2607 |
| „ 16. | 2631 |
| „ 17. | 2623 |
| „ 18. | 2606·6 |
| „ 19. | 2624·6 |
| „ 20. | 2614·7 |
| 6) | 15706·9 |
| | 2617·8 mean specific gravity, |

Which agrees very nearly with that given in the Tables.

Adopting, then, the former expression $x = \frac{(S-f)\,s}{(S-s)\,f}c$ when $x$ is the quantity of quartz—S specific gravity of Gold as settled by the experiment, 18300, s the specific gravity of quartz similarly determined, 2618,—$c$=480, or the number of grains in an ounce, f varying number from 18000 to 7000. The following Table will show the deduction to be made for the impurities existing in Mount Alexander Gold when the specific gravity of the sample falls between the numbers in the Table, the scale of which is sufficiently extensive to embrace all the average specimens, and which can easily be carried lower if necessary :—

| Specific Gravity of Sample. | Weight of Sample. | Quantity of Gold. | Quantity of Extraneous Matter. | Value of Gold. | | Loss. | |
|---|---|---|---|---|---|---|---|
| | | | | s. | d. | s. | d. |
| 18000 | 480 | 478·66 | 1·34 | 79 | 9·1 | 0 | 2·69 |
| 17000 | | 473·87 | 6·13 | 78 | 11·53 | 1 | 0·26 |
| 16000 | | 468·48 | 11·52 | 78 | 0·75 | 1 | 11·04 |
| 15000 | | 462·37 | 17·63 | 77 | 0·53 | 2 | 11·26 |
| 14000 | | 455·39 | 24·61 | 75 | 10·58 | 4 | 1·21 |
| 13000 | | 447·34 | 32·66 | 74 | 6·48 | 5 | 5·31 |
| 12000 | | 437·93 | 42·07 | 72 | 11·66 | 7 | 0·13 |
| 11000 | | 426·82 | 53·18 | 71 | 1·45 | 8 | 10·34 |
| 10000 | | 413·49 | 66·51 | 68 | 10·79 | 11 | 1·0 |
| 9000 | | 397·20 | 82·8 | 66 | 2·23 | 13 | 9·56 |
| 8000 | | 376·83 | 103·17 | 62 | 9·5 | 17 | 2·29 |
| 7000 | | 350·65 | 129·35 | 58 | 5·14 | 21 | 6·61 |

This Table needs but little explanation : the value of the Gold is deduced from that given in the former Table opposite the specific gravity 18300, which is here taken as the point of commencement. It will be seen on inspection that a large decrease in the specific gravity of a sample does not produce a corresponding diminution in its value; for instance, a decrease in the specific gravity from 18300 to 12000, or upwards of 33 per cent., only takes off about 10 per cent. of the value.

The following experiments will show the extent to which the Table may be trusted in determining the quantity of Gold in any mixed specimen :—

| | Grains. |
|---|---|
| 21. Weight of specimen in air . . . . . . . | 1375 |
| Weight in water . . . . . . . . . . | 1276·75 |
| Difference . . . . . . | 98·25 |

$$\frac{1375}{98{\cdot}25} \times 1000 = 13994{\cdot}9 \text{ specific gravity.}$$

By referring to the Table it will be seen that a specimen whose specific gravity is 14000 contains 24·61 grains of quartz in an ounce; as this specimen weighed 1375 grains, the quantity of quartz, according to the Table, would amount to 70·49 grains while by independent calculation the quantity was found to be 69·835 grains, a difference not worthy of notice.

22. Weight of mixed specimen of Gold and Quartz—

| | Grains. |
|---|---|
| In air . . . . . . . | 111·75 |
| In water . . . . . . . | 102·60 |
| Difference . . . . | 9·15 |

$$\frac{111{\cdot}75}{9{\cdot}15} \times 1000 = 12231{\cdot}1 \text{ specific gravity.}$$

| | |
|---|---|
| Weight of Quartz according to Table . . . . . | 9·28 |
| ,, by calculation . . . . . | 9·22 |

23. Mixed specimen of Gold and Quartz—

| | Grains. |
|---|---|
| Weighed in air . . . . . | 236 |
| Weighed in water . . . . . | 209·75 |
| Difference . . . . | 26·25 |

$\frac{236}{26 \cdot 25} \times 1000 = 8990 \cdot 4$ specific gravity.

Weight of Quartz by Table, 82·8 grains to the ounce, or 40·7 grains in the specimen.

24. Specimen of Gold and Quartz—

| | Grains. |
|---|---|
| Weighed in air . . . . | 103· |
| Weighed in water . . . . . | 96·75 |
| Difference . . . | 6·25 |

$\frac{103 \cdot}{6 \cdot 25} \times 1000 = 16480$ specific gravity.

Quantity of Quartz by Table, 1·95 grains.

25. Specimen of Gold apparently clean—

| | Grains. |
|---|---|
| Weighed in air . . . . . | 175 |
| Weighed in water . . . . . . | 165 |
| Difference . . . . . | 10 |

$\frac{175}{10} \times 1000 = 17500$ specific gravity.

Quantity of Quartz 1·41 grains.

26. Large specimen from Mount Alexander—

| | Grains. |
|---|---|
| Weighed in air . . . . . | 1311·06 |
| Weighed in water . . . . . | 1219·81 |
| Difference . . . . | 91·25 |

$\frac{1311 \cdot 06}{91 \cdot 25} \times 1000 = 14367$ specific gravity.

Quantity of Quartz from Table, 60·22 grains.

27. Specimen from Mount Alexander—

| | Grains. |
|---|---|
| Weighed in air . . . . . | 963·935 |
| Weighed in water . . . . . | 899 12 |
| Difference . . . . | 64·815 |

$\frac{963 \cdot 935}{64 \cdot 815} \times 1000 = 14872.$

Quantity of Quartz from Table, 37·05 grains.

28. Five small pieces of Gold from Mount Alexander, apparently clean and free from quartz—

| | | Grains. |
|---|---|---|
| Weighed in air | . . . . | 365·1 |
| Weighed in water | . . . . | 344·23 |
| Difference | . . . . | 20·87 |

$$\frac{365{\cdot}1}{20{\cdot}87} \times 1000 = 17494 \text{ specific gravity.}$$

Weight of Quartz by Table, 2·92 grains.

These same specimens on being fused in a crucible, and when the slag which adhered to the button was removed, weighed 361·625, the difference, 3·475, being the actual amount of the impurity contained in them. The specific gravity of the metal being 18688, instead of 18300, will explain this difference.

29. A quantity of Gold-dust well cleaned—

| | | Grains. |
|---|---|---|
| Weighed in air | . . . . | 960·43 |
| Weighed in water | . . . . | 905· |
| Difference | . . . . | 55·43 |

$$\frac{960{\cdot}43}{55{\cdot}43} \times 1000 = 17337 \text{ specific gravity.}$$

Quantity of Quartz per Table, 8·68.

This Gold-dust being fused into a button of Gold, and cleaned from the slag, weighed 955 grains, the difference between this and the original weight being 5·43 grains,—therefore the allowance in the Table is in excess. In this case it is possible that the specific gravity of the matter in combination with the Gold was inferior to that of quartz, in which case it would less to require bring down the specific gravity to the point shown in the experiment.

30. Twelve specimens of Gold crystallised in various forms—

| | | Grains. |
|---|---|---|
| Weighed in air | . . . . | 83·0 |
| Weighed in water | . . . . . | 78·195 |
| Difference | . . . | 4·805 |

$$\frac{83}{4{\cdot}805} \times 1000 = 17273 \text{ specific gravity.}$$

31. Small specimens of Gold in the form of a crystal—

| | | Grains. |
|---|---|---|
| Weighed in air | . . . . | 29·45 |
| Weighed in water | . . . . . | 27·75 |
| Difference | . . . | 1·70 |

$$\frac{29{\cdot}45}{1{\cdot}70} \times 1000 = 17323 \text{ specific gravity.}$$

32. Golden crystals—

| | Grains. |
|---|---|
| Weighed in air . . . . . | 152·75 |
| Weighed in water . . . . | 143·81 |
| Difference . . . . | 8·94 |

$$\frac{152·75}{8·94} \times 1000 = 17086 \text{ specific gravity.}$$

These specimens being apparently clean, it would appear that there is something in the arrangement of the particles in a crystalline form which tends to diminish the specific gravity of the mass; or, what is perhaps more probable, that there is a central nucleus round which the particles of Gold have arranged themselves in a crystalline form.

The previous experiments and the deductions from them, especially as regards the comparative amount of Gold and extraneous matter in mixed specimens, apply in strictness only to Gold from Mount Alexander: but there is much that will apply to Gold from California and New South Wales; or, indeed, to that from any part of the world which is alloyed principally with Silver.

I have not been able to procure specimens from California or from Sydney sufficient to enable me to carry on a series of experiments with regard to them, but I am in possession of the analysis of a considerable quantity both from California and Sydney; and it will be interesting to compare the results obtained by analysis with those which I have deduced from my experiments,—and the Society will then be able to judge of the amount of confidence which can be placed in the Tables which form part of this communication.

First, with regard to the Gold from California.

The quantity of metal forwarded to the assayer was 21 lb. 9 oz. 6 dwts.; this, when melted and cast into an ingot, weighed 21 lb. 1 oz. 0 dwts. 12 grs., showing a loss from the presence of extraneous matter of 8 oz. 5 dwts. 12 grs. Upon analysis this quantity of metal was found to contain 527 dwts. of pure Silver, or at the rate of 21 dwts. 13 grs. in the pound; or the proportion of Gold to Silver in metal was as 9·3 to 1.

If a reference be now made to the first Table to ascertain the specific gravity of a specimen in which the Gold bears to the Silver the proportion stated above, which, when ounces are taken as the total weight, will be equivalent to 433·4 grains of Gold to 46·6 of Silver, we shall find that it lies somewhere between 17700 and 17900; and by making the proper allowance for the difference, the actual specific gravity will be 17809.

Now, the value given in the Table of an ounce of Gold alloyed with Silver, whose specific gravity is 17·809, is 77*s.* 2·79*d.*; and in reference to the return of sales it was found that 21 lb. 1 oz. 0 dwts. 12 grs. of mixed metal was valued at 960*l.* 5*s.* 3*d.*, which is at the rate of 75*s.* 10·8*d.* per ounce: the value of the Standard Gold, however, is taken in this return at 77*s.* 9*d.*, whereas in the Tables it is calculated at 77*s.* 10·5*d.*, or 1½*d.* per ounce more. The value too of standard Silver is taken at 60⅛, whereas in the Tables it is taken at 60 Making allowances for these differences, the value of the mixed metal will be 77*s.* 0·4*d.* per ounce, which approximates very closely to that given in the Table. From this it appears that Gold from California, having a specific gravity of 17800 or thereabouts, is inferior in value to the Standard Gold coinage of England to the extent of about 1*s.* per ounce.

With regard to the Sydney Gold, the data in my possession are not so precise as with reference to Californian Gold: they consist of account sales extracted from the "Sydney Morning Herald," and republished in the "Courier" newspaper of 17th March. From this it appears that eleven large pieces of Gold weighed before melting 4 lb. 2 oz.; after melting 3 lb. 6 oz. 15 dwts. 12 grs., showing a loss of 7 oz. 4 dwt. 12 grs. On assay these were found to be equal to 3 lb. 7 oz. 17 dwts. 9 grs. of Standard Gold. The quantity of Silver contained in these specimens is not given, but it may be got at by reference to the Table:—thus, 3 lb. 7 oz. 17 dwts. 9 grs., at the tabular value of 77*s.* 10½*d.*, is worth a certain sum, but 3 lb. 6 oz. 15 dwts. 12 grs. of native Gold is of the same value,—therefore one ounce of the latter will be worth 79*s.* 8·79*d.*; and on reference to the Table the specific gravity of Gold alloyed with Silver, worth 79*s.* 8·79*d.*, is 18255, and the quantity of Silver contained in an ounce 31·47 grains.

Some small pieces of Gold weighed before melting 11 lb. 3 oz. 18 dwts., and after melting 10 lb. 8 oz. 14 dwts. 12 grs., showing a loss from the presence of extraneous matter of 7 oz. 3 dwts. 12 grs. On assay these were found to be equal to 11 lb. 0 oz. 7 dwts. 15 grs. of Standard Gold; and the value of an ounce of metal is from this 80*s.* 1·04*d.*, and its specific gravity 18319.

Again, two lumps of Australian Gold weighed before melting 5 lb. 4 oz. 0 dwts. 12 grs. After melting 4 lb. 9 oz. 16 dwts. 12 grs.

The difference, 6 oz. 4 dwts., is the amount of extraneous matter. The assay showed these specimens to be equal to 4 lb. 10 oz. 12 dwts. 22 grs. of Standard Gold; and the value per ounce will therefore be 79*s.* 11·6*d.*, and the specific gravity 18300.

These latter results, agreeing as they do with each other, and with those deduced by experiment upon the Gold from Mount Alexander, establish beyond a doubt the relative value of the Australian Gold. It would be desirable of course to ascertain whether the Californian Gold, of which the assay has been given, was a fair average specimen; but this can only be arrived at by more detailed experiments. The only two specimens which I have been able to procure gave specific gravities of 17272 and 17625 respectively; the former probably containing some small amount of extraneous matter. We have no exact information as to the character of the extraneous matter in these specimens of Gold submitted to analysis, but if we assume it to be equal in gravity to quartz, we shall not be far wrong; and the following comparison will be interesting:—

The weight of all the specimens of Australian Gold was 20 lb. 9 oz. 18 dwts. 12 grs.; the weight after melting 19 lb. 1 oz. 16 dwts. 12 grs. The weight of extraneous matter 1 lb. 8 oz. 1 dwt., equal to 38·6 grains to the ounce. On reference to the second Table, it will be seen that the specific gravity of a mixed specimen containing 38·6 grains of quartz to the ounce will be 12369, and its value 73*s.* 6·6*d.* per ounce. The value given in the return as that of all the specimens is 913*l.* 10*s.* 1*d.*; but Standard Gold is taken at 77*s.* 9*d.*, while in the Table it is valued at 77*s.* 10½*d.* Making allowance for the difference, the return from this Gold would be 914*l.* 9*s.* 4*d.*, or at the rate of 73*s.* 4·46*d.*—a result very slightly different from that given in the Table.

The conclusion which I should be disposed to draw from the experiments which I have here submitted is, that the value of specimens of Gold, carefully washed and freed by the use of the magnet from magnetic iron ore, can be estimated with every necessary degree of accuracy by means of delicate scales; the specific gravity being an accurate test not only of the amount of extraneous matter mixed with such Gold, but also of the character and value of the metal itself.

The subject, however, is far from being exhausted. Accurate experiments on the specific gravity of Californian Gold are much wanted : analysis of Australian Gold, showing all the elements which enter into its composition, will be most valuable : inquiries into the molecular arrangement of those specimens which appear to be crystallised will be very interesting.

I trust, therefore, that other members of the Society will turn their attention to these points, and to such others as may appear to them to be of importance, and communicate the results to the Society; while I for my part will continue the series I have already commenced, extending it so as to include Sydney and Californian Gold, or that from any other country from which I am able to procure specimens.

---

NOTE.—The above paper was communicated by his Excellency Sir William Denison to the Royal Society of Van Diemen's Land, and published in their Transactions. The Editors have much pleasure in reprinting it in the present volume.

# PAPER V.

## Memoir and Estimate for a Breakwater formed of Diamond-shaped Piers of Masonry at intervals. Probable expense, 156,232*l*. 7*s*. for One Mile in Length. By Lieut.-Col. Cole, Royal Engineers.

### Memoir.

The enormous expense of a breakwater of loose stones; the virtual impossibility of forming a firm continued line of masonry in deep water; and the danger of filling up the anchorage by any continued line in harbours or bays where there is much silt, form a sufficient excuse for any feasible proposition tending to obviate the objections, and reduce the expense.

The subject has been suggested by propositions on foot for the security of the anchorage in Table Bay, which is unsafe about the months of June, July and August, from the force of the north-westerly winds.

Present opinions appear to be divided between an isolated loose stone breakwater, or a mole from the shore, wholly or in part of loose stones. In either case the line would be nearly as laid down in the subjoined plate No. III, as embracing the whole of the usual anchorage without getting into deeper water. Large quantities of sand, sea-weed, and other substances are drifted into the bay, and thrown ashore by these winds, and, it may be apprehended would fill up the anchorage close behind a continued line, as in all harbours having much silt where islands or other obstructions form dead water, both on the surface and under current; which latter, or a more superficial one on the north shore of this bay, carries a large portion of the silt to sea again. At Plymouth no formation of a spit or bank has occurred, owing to the clear river-stream passing through the harbour. At Cherbourg, the breakwater is not continuous, and its situation as regards the shore allows, apparently, a current in rear of it in the along-shore tides and winds. It is said, however, to have partially filled up towards the east end.

Present projects for Table Bay.

Probability of silting up.

A mole would here cause, probably, the filling up, not only of the anchorage but of the boat harbour. At present, the wave, during the north-west winds, takes a circular direction round the Chavonne Point, and on arriving at the boat harbour, comes head-on to the existing jetties, quickly filling up the space on the west side of them, when, solid, but not on the east, on which a free passage exists along shore for the current and silt in suspension; but this could not be the case round a mole, from the end of which a similar curved direction of the wave would leave the anchorage in dead water, and a spit would form, inside as well as outside. The return under-current, which probably prevents the silting up of every bay not having a river to clear it out, would be proportionally weak and inefficient.

A mole would likewise intercept the direct passage of boats and small craft along shore, and cause a mischievous, as well as useless expenditure for the first 600 yards. The site is too distant for a landing place, and a jetty for ships, to discharge, where convenient, would be preferable if made with timber, or bridged openings of masonry.

Expense of loose stone breakwater.

The expense of a loose stone breakwater in Table Bay would probably equal that for Plymouth, the depth being here less, but the price of labour and its efficiency being in the opposite scale; the price of large building stone here, delivered in the town, being 4*s.* 5*d.* per ton, which exceeds the general Plymouth prices for placing stones of from one to five tons weight in the breakwater. A line with frequent intervals clear to the bottom and of cheaper construction is therefore desirable. If formed of cribs filled with loose stones, it would be liable to the same fate as the Cherbourg Cones, although on the Canada canals such cribs have endured many years.

Interval breakwater.

Cribs.

Screw pile.

With the exception of the screw pile, in cases where there is sufficient depth of soil, there is no existing mode of meeting the above requirements, but by building in coffers of convenient size, and sinking them as hereafter shown. The proposer, undersigned, has arranged their plan with a view to destroy the action of the wave by its own force, as shown in the accompanying plans, sections and model * adapted to Table Bay as being more convenient for illustration. The size is adapted to six fathoms at low water, and allows the foundation timbers of the coffer to be framed without scarfing, but there is no material objection to any manageable size, especially as a larger one would possess more buoyancy in proportion to the first masonry wall built within it; would require less proportionate distance from front to rear of pier, and a greater interval might be allowed. The salients of each diamond pier, as shown in diagram in corner of plate No. 3, would receive the wave and glance it off right and left to meet a similar oblique action from the adjoining ones, continuing along the faces and their prolongation. The interval waves would be intercepted by these oblique ones, and neutralized. They would be further dissipated by the subsequent side expansion along the rear faces of the piers, and by the water falling obliquely from the top of the masonry piers in a heavy sea. Since the idea of this arrangement was conceived by the undersigned, he has endeavoured to find practical exemplifications of it, and has examined such pier-heads and sea-walls which meet the waves obliquely, and finds that it is fully confirmed as far as a parallel can be found, but the difference of size, site, and depth of water, and want of mutual reaction, prevent a perfect parallel. The continuance of the oblique action, however, has been found to continue three times the length of the face giving that action, its completeness being in proportion to the force and depth of the sea. Taking this observation as a guide, the salients of the trapezia are drawn at a distance equal to about three times that of the two faces of adjoining piers, viz., 200 feet. Each front face 30 feet, forming an interior angle of 120° at the salient; that of the rear may be more obtuse. The top is angular, as being cheapest and fulfilling its requirements better, as well as avoiding the full force of the wave. The shoulders, however, should be rounded as in plan and model, within the action of the wave. The left face of the diamond may be retired so as to preserve an angle of 30° beyond the perpendicular to the line of wind when from the west. In this case the gorge would require modification.

Proposed line of diamond-shaped piers of masonry.

Size.

Shape.

Influence of the piers on the sea.

Size and outline.

Outline.

Number of piers.

Twenty-seven of such piers would be required for one mile of breakwater, as in plate No. 3 and its diagram. The effect of these piers might be proved by the construction of two or three; and modifications, if necessary, be made; but it is probable that a contraction of the interval or the formation of a second line in chequers would be unnecessary. Even in this case the expense could be many

* The model may be seen at the office of the Inspector General.

times less than that of a loose stone breakwater or mole, which latter might be made if necessary on the plan now proposed with bridged intervals.

In a convenient soil, the screw pile would, it is presumed, be much cheaper by disposing them in a similar manner, with grooves to receive a plank facing to about six feet below low water to act on the sea, and be removed when decayed. The duration of the iron screw-piles itself in sea-water is a matter of experience. Screw pile.

The difficulty of building in deep water it is to be hoped may be met by the mode proposed as in model, and plates Nos. 1 and 2, and in specification subjoined, by the exertion of unremitting care and judgment in buoying and loading the coffer so as to sink it as required. No precedents are known to assist in such depths in the sea. Building in deep water.

With respect to intervals, the same want of precedents exists, though it is believed the subject has been mooted, and perhaps the Cherbourg Cones may have been constructed partly with the same views. As it is, however, they afford no guide, except as a warning against trust in timber as a permanent support, particularly where exposed to the action of the sea. No precedents.

Piles, however, framed and notched in the coffer, so as to be driven by the weight of the masonry, are proposed as an assistance to the buoyancy in steadying the coffer when the points reach the ground, and as permanently securing the foundation both as ordinary, and, in part, as sheet piles. They should vary in length below the coffer from one foot to fourteen feet, or more, according to the depth and consistency of the soil, and its freedom from rock or large stones. Table Bay is said not to have more than five or six feet of soil over the rock. The compressed soil would pass out between the pairs of piles, till a uniform bottom were formed. The coffer may remain to *p* of section below low water, when the pier is finished, and secure; and the top of timber, cut off and sloped as in model and section, so as to afford no hold to the rising and falling wave (*p* of section). Flat iron ties, rounded at the screw-heads, as shown in Plate No. 1, Fig. 3, will be requisite, as they must remain until the whole masonry be finished, and timber ties through the masonry would be prejudicial by their size in decay. Temporary timber struts from the framework, *g g*, of plan and section, prevent collapse of the coffer, and might be removed to the back of wall as it progresses; *g g*, however, may remain. Construction. Flat iron ties. Temporary struts inside the coffer.

The heads of the iron ties exposed to sea water may be galvanised or zincked over, for one foot into the wall, or as some authorities propose, tarred over, or covered with anti-corrosion, if danger be apprehended to the masonry by oxydation of the iron, as in the case of exterior cramps, &c. It may be in this case, that as the end only would be exposed, it would not separate in flakes, as usual, but in powder, which would fall to the exterior, and cause no expansion. They would be preferable, also, as bending, in case of a slight settlement of the masonry, without straining the coffer. Oxydation of iron work.

As a further support to the piers, a slope of stones, of large size, may be thrown outside the salient and rear angles; on the salient, sufficient to form a slope of three to one, with ten feet high at the angle; two to one at the rear angle, with fifteen feet at the apex, forming buttresses in shape of a section of a cone, as shown in plan and section, which, with the oblique action of the sea on the pier, seems to make it more than equal to any probable force. The intervals should be free to the bottom. Broken stones at front and rear angles.

Such a pier would, with modification, form the foundation of a lighthouse, battery, or other appendage to the breakwater, whether of masonry or screw-pile, Lighthouse. Battery.

wherever rock or moveable sands do not exist. Even in the latter case it might be found that very long piles to the coffer might bite in the solid ground below.

Piers of bridges, &c.

Piers of bridges, in very deep water, might, it is conceived, be constructed in the same coffer.

Harbours of refuge.

In the case of harbours of refuge, the intervals might be stopped, in war, by booms and chains, secured so as not to injure the piers. The booms might be made so as to act as a floating breakwater, which might be moored to the piers.

Difficulties to be apprehended from winds and sea.

The regularity of the winds affords peculiar facility of execution in Table Bay, during eight months of the year, when easterly winds prevail off-shore, or a light south-westerly eddy round the Cape, if the easterly wind has much southing, affecting the harbour only, while an easterly wind blows on the north shore. No wave rises to affect a large body, anchored or moored. A westerly wind during these months is rare, and generally light. To limit the chances of difficulty, the foundation of coffer may be put together in-shore, and floated out, as required, making use of previously constructed piers as a shelter, if necessary, till the piles are near the ground; after which a pier of the size proposed may be secured in its site in a few hours, and finished in about three weeks.

Floatage power.

Large casks fixed to the coffer guards would be the safest and most convenient floats to assist in buoying the coffer, with lighters or other vessels to assist in steadying it. It may, however, be dangerous to trust much to cables or chains as suspenders. In variable climates, or wherever there are dockyards, variable winds may be guarded against by large vessels as shelter or floating power. The buoyancy of the coffer itself will admit (in its first, ten feet of height) of building a well all round, six feet six inches high, and five feet thick, of the nature shown in plans and specification. The addition of a second ten feet of coffer will allow six feet additional of wall. The whole coffer will float about twenty-four feet of wall, or two-thirds of its height, without the assistance of casks, &c.

Returns or ends to breakwater.

With submission to the great authorities, who place returns at each end of the breakwater, I would not advise their use, as the set from each end would neutralise each other, and the two would prevent the formation of absolute dead-water, and formation of a spit. They are, at all events, unnecessary in an interval breakwater. Any trace, however, would suit these piers, with the precaution of throwing back the faces about thirty degrees from the wind.

Height of waves.

No wave in Table Bay exceeds six feet perpendicular from the trough to the crest, so that the masonry would never be exposed more than three feet below low water; beyond this depth the sea would lose the momentum of the falling wave, and at six or eight feet the disturbance would be immaterial, according to Professor Whewell and other authorities.

The exaggerated accounts of the height of waves arise, perhaps, from taking the slope instead of the perpendicular, or from want of consideration that when two vessels are hidden from each other, the deck is frequently at the bottom of the wave, in pitching and rolling, and that the observer's eye and the crest of the next wave make a great angle with the horizon. In the experience of the undersigned, in many voyages, no wave of the Atlantic exceeds eleven feet perpendicular. These questions and others present themselves for consideration in weighing the feasibility of this project, though the height of waves is of minor importance, as well as the depth of disturbance, except as regards the depth of plank-facing requisite, if screw-piles be used.

The destruction of timber by the worm below low water, does not apparently take place, and, as well as the duration of the timber, is also of minor importance.

## Specification.

### *Coffer.*

Lay *a a*, as shown in plan and section, of round pine, 1 foot in diameter, about 5 feet apart, so as not to interfere with the subsequent insertion of the piles, the ends to be flush with the outside of *f f*, against which they should be firmly wedged. Into *a a* notch and pin *b b*, which form the faces of the bottom, of sound square timber, 1 ft. 6 in. square, strapped and bolted at the angles. Through *b* pass a bolt with a bar-nut outside. Pin *c c* on *a a* of half round timber, 1 foot in diameter, breaking joint with each other. Over *b b* and *c c* lay a solid flooring, *d*, in two thicknesses of 6 inches each, breaking joint, and caulked, pitched in the joints, notched and pinned on *b b* at the ends; and on *c c*, heads flush with outside of *f f*, but not to interfere with the insertion of the latter, against which they are afterwards wedged. Lay the course of half round timber, *e e*, 1 foot in diameter, dovetailed and pinned to each other, and between each pair of piles, *f f*, the angles of the frame to be strapped and bolted together; the front ties of hard wood. To be filled flush with concrete. The piles, *f f*, to be next inserted against the dovetails of *e e*, and on *b b*, of 1 ft. 19 in. timber, and round points, and shod below the bottom. The bar-nut of the bolt through *b b* will then be turned across the piles, between each pair of which there will be straining pieces of timber, at convenient vertical distances; strap round each pair of piles below *a a*. The piles must be perfectly vertical, to prevent strain in driving, which is done by the weight of masonry, &c., to be of length, according to the soil below, and about 10 feet above bottom, forming the ribs of the coffer, which are continued upwards, as required. All bolt-heads and nuts to be countersunk and covered; the angle-tie in front to have a pile on each side, and, as on each angle, to have bulks vertically to fill in between the piles, and be pinned, strapped, and bolted together. The two-inch planking to be laid over the piles and rails, or straining-pieces; caulked and pitched. The coffer to be 5 feet above spring tides, to *h* of section. All the masonry is secure. Girders outside, as shown in section, and strapped and bolted together at the angles. The sides of coffer to be supported as in memoir and plan and section.

### *Masonry.*

An average thickness of 5 feet to be built round the interior of coffer, of hammer-dressed granite, well bonded, the stones not less than 3 feet to 6 feet in length, and 2 feet depth of bed and face, with thorough stones, every 10′ of each, 2′ higher, uncoursed, and bounded vertically as well as horizontally; to be rebated and checked; cramped and dowelled with oak or teak dowels, as shown in plan, elevation, and section. The dowels of the surface-stones to be fox-wedged, and perfectly dry when inserted. Thin 5′ work to be laid in cement of water and common lime, mixed with puzzuolana, or Portland lime, for face-joints and beds, to a distance of 2′ from the face, and the whole 5′ grouted with cement every 2 feet in height, using as little water as possible. The foundation of the masonry to be laid and grouted with the same. Tail bond to be left as efficient as possible at the back of the outer wall, to bond with the heart of the pier, which may be of ordinary rubble masonry or concrete, mined or grouted with water-cement. This work, as well as the wall, will be flushed occasionally, to receive the flat iron ties mentioned in Memoir. The quoin stones to be dovetailed and cramped, as shown in plan, without interfering with the usual header and stretcher course. The masonry to be carried up, as stated in memoir, according to the buoyancy of the coffer, and its assistant casks, or other floats.

In carrying up the wall, the struts from *g g*, to support the sides of the coffer, will be shifted to the back of the wall, and finally removed, as the heart of the pier is carried up.

*Iron-work*, as in memoir and in plan and section.

*Loose stones* outside the salient and rear angles of each pier, as detailed in memoir.

ESTIMATE OF THE EXPENSE OF ONE PIER.

| | £ | s. | d. |
|---|---|---|---|
| 14,529 cubic feet of timber in coffer wrought, framed and fixed, strapped and bolted, as in specification, at 3*s*. | 2197 | 7 | 0 |
| 19,360 cubic feet of granite masonry, laid in cement, wrought and dowelled as in specification, at 2*s*. 6*d*. | 2420 | 0 | 0 |
| 12,408 cubic feet of rough rubble masonry, or concrete in heart of pier, at 10*d*. | 517 | 0 | 0 |
| 560 tons of granite stones from 1 to 5 tons each in weight, thrown in at salient and rear angles, according to specification, at 4*s*. 6*d*. | 126 | 0 | 0 |
| | 5260 | 7 | 0 |
| Add one hundredth for contingencies | 526 | 0 | 8 |
| Total for one pier | 5786 | 7 | 8 |
| | | | 27 |
| Total for 27 piers, forming 1 mile in length of breakwater | 156,232 | 7 | 0 |

The probable expense of a diamond breakwater, formed with the screw pile according to memoir, from such data as are authentic, appears to be about £18,000, for Algoa Bay, or others having deep soil.

P. COLE,
Lieut.-Col. Royal Engineers.

*Jan.* 10, 1851.

---

LIEUT.-COLONEL COLE, ROYAL ENGINEERS, TO THE INSPECTOR-GENERAL OF FORTIFICATIONS, SUBMITTING TO HIS JUDGMENT A PROPOSITION FOR A BREAKWATER ON A NEW PRINCIPLE.

CAPE TOWN, *January* 10, 1851.

SIR,—

I have the honour to inform you that I have forwarded, under the charge of Capt. Howarth, Royal Engineers, who goes home in the ship "Jane Briton," by which this letter is also posted, a memoir, specification, plans, estimate and model of a breakwater on a new principle, as far as I am aware, which I submit to your judgment, and should it be approved by you, I request you will be kind enough to have it brought forward in the exhibition of this year, if suitable to it, in which case Colonel Reid's usual kindness will, I feel confident, assist its introduction, or if not, in such other manner as you both may judge best.

I have not proposed it here, although framed with reference to the sounding and nature of this bay, because I wish to avoid competition with other projects,

and because it will meet with a better ordeal at home, even if it does not go beyond your office. I have, however, mentioned it to such persons as are best qualified to judge of its usefulness, and they all conceive it practicable, and adapted to its proposed end.

For Algoa Bay and other deep soils or bottoms, the principle if carried out with the aid of the screw-pile, would be still easier and cheaper; the masonry coffer and pier being about one-tenth the expense of the ordinary breakwater, and with help of the screw-pile and plank facing, as stated in memoir, it would be one-seventh the expense of the masonry one—as far as I am able to judge from what I have read of that pile.

I am indebted to Lieut. Smith for the drawings and to Mr. Penketh for the model, and for their kind assistance in framing them from my rough plans and specifications. I have endeavoured to make the memoir as short as possible, but in considering the feasibility and difficulties to be encountered, as well as the principle on which the proposition is founded, I have been forced to enter on several subjects, the results only of which I have transcribed.

I have the honour to be,

Sir, your most obedient humble servant,

J. COLE,

To the Inspector General of Fortifications. Lieut.-Colonel, Royal Engineers.

---

*29th Sept.* 1851.

This system of building to sink as the work proceeds, does not appear new, and I believe the practical difficulties in the execution especially in deep water and uncertain sea, has been the cause of its not being more adopted.

The proposition of the diamond shape to the piers would lessen the action of the wave against them, but with intervals of 150 feet I doubt whether the wave would be sufficiently broken to secure the anchorage behind. The piers also appear small to stand perpendicular against such a swell as often occurs at the Cape, on a base of only 30 feet at the widest part, and a foundation not well ascertained. If on sand, which appears probable, they would be very insecure, with a height of 40 feet. It might be suggested to Colonel Cole that, as there is stone on the spot, the alternate piers might be connected by loose stone to nearly their height in addition to what he recommends at their bases.

(Signed) G. J. H.

---

*29th Sept.* 1851.

I quite concur in the above remarks :—I believe the Caisson system has been generally rejected by engineers.

The question is not one requiring the consideration of our corps at present, and I am not sufficiently confident of the advantages to wish to bring it forward; but there can be no objection whatever to Colonel Cole putting it into the Corps' Papers, or laying it before the public in any way he pleases.

(Signed) J. F. B.

---

*30th Sept.* 1851.

Returned to Lieutenant-Colonel Cole, with the plans, memoir, specification, and estimate, and transmitting for his information, copies of minutes on the subject (above) from the Assistant Inspector General and the Inspector of Fortifications.

E. MATSON, A.A.G.

# PAPER VI.

## To the Editors of the Royal Engineer Professional Papers.

Gentlemen,—

Having seen in a pamphlet published by Lieutenant-Colonel Waddington, that he has requested of you to insert in both your works his reply to my strictures on his battle of Meeanee, I hope you will do me the favour to append the following comments if you comply with his request.

1st. Lieutenant-Colonel Waddington has shown that I mistook the time he meant, when he said the Shikargah wall was crowded with matchlock men; I apologise for the error, but was misled by his own expression, which he has in his reply inadvertently misquoted as being "*the approach of our column*," whereas the original passage, repeated at page 7 of his pamphlet, is simply "*on our approach*" and it was natural to suppose that referred to the advance in order of battle.

2nd. For the duration of the action it would appear Lieutenant-Colonel Waddington reckoned only from the arrival of the troops on the bank of the Fullailee, whereas I reckoned from the first shot, and that was about nine o'clock. But we differ also as to the duration of the hand-to-hand fighting; and upon that point I will give an illustration of the difficulty of agreement. Five officers assured me separately that they had looked at their watches when the first shot was fired at Waterloo; and yet all differed—not by minutes, but even as much as two hours! Wherefore I must be pardoned if, with respect to Meeanee, having the opinions of three officers, besides the General-in-Chief, in opposition to Lieutenant-Colonel Waddington's opinion on a point so easily mistaken, I adhere to my own statement.

3rd. For the numbers killed, Lieutenant-Colonel Waddington relies on his own observation, made the day after the battle,—the General judged from the observation and counting of several officers, and I find the following marginal note in his handwriting, on the Colonel's pamphlet:—

"I remember that the enemy sent to me for leave to bury their dead, which I granted. This, as I recollect, was the morning after the battle, and would account for Colonel Waddington's seeing so few. Numbers would have been carried away or buried."

There remains this question: Who originated the cavalry charge? Colonel M'Pherson's or Captain Thompson's notes, given in my former strictures, would, I thought, have been sufficient on that head; but Colonel Waddington still offers evidence in favour of Captain Tucker's claim, and thinks that officer deserves the highest praise. I will presume to say, that for a captain to carry off a general's reserve in the midst of a battle without orders, deserves, not praise, but severest censure, and happily the following letter from Captain Thompson shows that Captain Tucker was not guilty of that impropriety; that his letter and that of Captain Bazett were written under a misconception of what had passed, and that Colonel Waddington has mistaken Captain Thompson's second arrival, to enforce the first order, for his first arrival to give that order.

EXTRACTS FROM CAPTAIN THOMPSON'S LETTER.

"CALCUTTA, *Feb.* 21, 1852.

"My dear General,—I have just received a pamphlet from Colonel Waddington, in which he makes out that at Meeanee, Colonel Pattle never received any order to charge from you, or if he did, it was after the cavalry had charged; the facts are as follows.

"When I was sent by you to order the advance, the cavalry were *considerably* in rear of the infantry; Major Story gave the order to 'advance by threes from the right of squadrons,' and marched up to the infantry, where I am told he halted, but by whose order he did halt I do not know; it was at this time that the regiment in front 'fell into some confusion and came to the right-about'— when, according to Captain Bazett's account, Captain Tucker urged Colonel Pattle to charge, although the Colonel had received the order to do so from M'Pherson and myself some minutes before.

"In Captain Bazett's letter (page 35) he says the advance was made, without any order to that effect having REACHED Colonel Pattle from the General, on the urgent entreaty of Captain Tucker; Captain Bazett, being with the left troop of the left squadron, was not in a position to know what order I conveyed to Colonel Pattle, as I met him between the cavalry and infantry (as stated in my letter of the 22nd May, 1844) and Colonel Story was in front of the centre of the regiment, when I gave him your order.

"Captain Bazett is so far correct when he says, 'I heard that an officer came with the order a few minutes later,' for you AGAIN ordered me to hurry on the cavalry, but by the time I reached the left of the line they had dropped into the Fullailee and charged. Had the 9th not halted close in rear of the Infantry, there could have been no dispute as to who ordered the cavalry to advance; for Colonel Pattle was not with the regiment but between the cavalry and infantry, when Colonel Story received the order from me—and advanced by threes from the right of squadrons.

"I have not written to Colonel Waddington, neither do I intend to do so, but I think it only fair that I should let you know the facts of the case, as Sir William Napier may wish to reply to Colonel Waddington."

This I think conclusive, and I remain, gentlemen,

Your obliged servant,

WM. NAPIER,

Lieut.-General.

# PAPER VII.

## Siege Operations, Ancient. By Lieut. Yule, Bengal Engineers.

The classical manner of siege, by means of great wooden towers, used as movable cavaliers, exactly as it is depicted in the sculptures of Egypt and Nineveh, continued to be practised in the middle ages, when these cumbrous machines are often spoken of under the name of *belfreys*, or *cat-castles*.* The advance of these was backed by a mechanical artillery, which, however slightingly we may be disposed to think of it, was directed with sufficient force and accuracy to effect practicable breaches.† The latter object was frequently attained, as in ancient times, by running mines under the walls, which were propped up with dry timber, ready to be fired at the right moment. The use of cannon must soon have abolished the system of attack by movable wooden towers,‡ but the old mode of mining continued to be employed for a century and a half after the introduction of gunpowder. Mines charged with powder were first tried by a Genoese engineer at the siege of Larzanella, in 1487, on which occasion they failed.§ Peter Navarre, one of the earliest modern engineers of eminence, had witnessed the attempt, and repeated it on several occasions in the service of Spain; till, in 1503, his efforts were crowned with complete success in the capture of the Castel del Ovo, at Naples—a fortress of which Froissart had remarked, a century before, that it was "impossible to take it but by necromancy, and the help of the devil." ‖

* *Beffrois* and *chas chasteils*. The latter name was given to this engine, according to Geoffrey de Vinsauf (iii. 8. Bohn's edition), because like a cat it crept up and adhered to the walls. *Katze* is still the technical German term for a cavalier. As an early example of the use of these engines in medieval history, may be mentioned the attack of Paris by the Northmen in the ninth century: see *Daniel's Hist. de la Milice Française*; and, as a later, the campaign of St. Louis in Egypt, where we find them used on both sides in the attack and defence of field entrenchments even.—*Joinville's Memoirs.*

† Acre when besieged by the Crusaders was breached by engines casting stones. At that siege also, a single stone from one of King Richard's mangonels was known to kill twelve of the garrison.—*Vinsauf.* In one of the English sieges in Scotland, the carcases of dead horses were cast into the town from the besieger's engines. So also Froissart tells us (book i. chap. 106), that the French besieged Auberoche (1344), having caught an English messenger, tied his letters round his neck, thrust him into one of the machines, and shot him into the fortress. At the same siege the vertical discharge of stones was so heavy that the garrison were confined to vaulted rooms on the ground-floor.

‡ So late, however, as 1453 we find the Turks at Constantinople, using the ancient towers and battering-rams in combination with heavy artillery.—*Gibbon*, lxviii. An attempt was made to revive the use of the ancient wooden towers when Steinwyck was besieged by Prince Maurice of Orange in 1592. The engine as devised by a certain Captain Cornput, of Breda, was of nine stories, each story twelve feet high. It was moved on rollers up to the edge of the ditch, where at first it enabled the musketeers to drive the defenders from the ramparts, and even from the streets of the town. But two guns brought to bear on it soon knocked the two top stories to pieces, and then no one would venture on it.—*Van Metteren, Hist. des Paysbas*, liv. xvi. The Royalists, during the civil war in 1645, made a similar engine for the attack of Canon Frome, near the Malvern Hills; but it was captured by the Parliamentary troops before it could be used.—*Grose's Mil. Antiquities*, vol. i. 385.

§ The theory, at least, of mining with gunpowder seems, however, to have been suggested by Francesco, of Siena, the father of modern fortification, some years previously.

‖ *Froissart*, book ii. ch. 87. We find the old and new modes of mining used in combination by Peter Navarre, at the siege of the Castle of Milan about 1515.

The attack of places in the 16th and early part of the 17th centuries, when not confined to blockade aided by elaborate chains of forts,* appears to have consisted generally of two approaches indifferently defiladed, sometimes by a zigzag trace, but oftener by frequent redoubts; by short places of arms parallel to the front, the parapets of which were made high enough to cover the direct trench in their rear, or by traverses at right angles to the trench; sometimes the approaches consisted of two long defiladed lines starting from distant points of the intrenchment, and crossing one another near the glacis.† In both cases the approaches were united near the counterscarp by a parallel or crowning lodgment. The principal battery was established with the earlier part of the approaches and between them, sometimes having another on each flank. These batteries directed their fire on the town and works indiscriminately, and were usually contained in redoubts or forts carefully strengthened.‡ In the earlier part of the period mentioned the batteries were raised to a great height, in order to command the attacked ramparts; hence they are frequently termed *mounts.* §

As the works of approach drew near the place the saps appear to have been either carried on as regular galleries blinded with timber,‖ or masqued at short intervals by wooden frames (called *chandeliers*) filled with fascines, placed from side to side athwart the trench which passed beneath them, or planted in advance of each other in direct *échelon.* ¶ But for these we see substituted, as early as

* As in Spinola's celebrated capture of Breda in 1625.

† All these modes of approach are described by the Chevalier Antony De Ville, in his book of Fortification (1628). We give an early example of zigzag approaches in fig. 1, plate I., which represents the attack of Groningen by Prince Maurice in 1594, from a contemporary Dutch history of the Revolt of the United Provinces. Approaches defiladed by redoubts are shown in fig. 2, which is a part of the attack on Breda by Frederic Henry of Orange in 1637.

‡ See in fig. 3, plate I., one of Spinola's batteries against Breda (1625), from the Latin narrative of the siege by the Jesuit Herman Hugo (Antwerp, 1629).

§ See these mounts represented in fig. 2, plate II., which has been traced from a large plate of the siege of Grave by Alexander Farnese, Prince of Parma, in 1586, contained in the Dutch history before referred to. The method of constructing these great cavaliers is described by De Ville. At Steinwyck, in 1592, some of the batteries were nineteen feet high. They were used up to a late period by the native Indian powers. "At the siege of Tellicherry in 1782, conducted by one of Hyder's generals, after several vain attempts in the usual style of attack, he constructed a cavalier battery of the nature alluded to. It was formed of trunks of trees and earth rammed between the intervals, with guns at the top which were elevated to a sufficient height to overlook the place. The fate of this particular work is not recorded, but as the siege was raised, and most of the besiegers, with their guns taken in a sally by the garrison, it is fair to conclude that it was not found to answer the end proposed. Another example occurred about thirty years before, when Clive was besieged in Arcot by Chunda Sahib. A house in the Pettah near the rampart, served as the base of a mound, which was made by the besiegers sufficiently high to see into every part of the fort. The garrison waited until it was completed, and then a few shots brought down the whole mass."—*Lake's Sieges of the Madras Army*, p. 222.

‖ "Les galleries sont certains chemins couverts qui sont faicts pour pouvoir venir aux fossés et remparts de la ville; ce sont des entrées voutées, lesquelles sont si larges qu'un chariot y peut entrer. Elles sont faictes de terre, et en haut elles sont couvertes d'ais [*planks*] soustenus de masts et gros bois et puis couvertes de terre. Elles servent pour venir jusquesaux fossés de la ville, et à cette fin les ouvriers jettent tousiours la terre devant eux par un trou qu'on y laisse, et par ce moyen allongent tousiours les galleries jusques à ce qu'ils soyent venus jusques aux remparts ou boulevarts de la ville . . . ce que nous avons veu avec grande admiration, devant la ville de Grave."—*Van Metteren, Hist des Paysbas*, liv. xxiv.

¶ Both of these methods of sapping are indicated in the attack of Groningen, fig. 1. plate I. For the chandeliers in De Ville we find substituted traverses formed of large gabions placed on baulks which cross the trench from side to side, fig. 4. Chandeliers were also often planted at different points where no real work was intended, to distract the attention and fire of the garrison. Lake mentions them as being used by Hyder Ali's French engineers at the siege of Vellore, in 1781; p. 208.

1629, in the attack of Bois-le-Duc, by Prince Frederic Henry, a regular double sap with overlapping traverses, exactly such as is now taught in our military schools.* On the crest of the glacis we find counter-batteries against the flanks, as well as breaching batteries. Breaches were however generally completed by mining; the gallery of descent into, and passage of the ditch, accomplished very much in the manner still taught—the latter, however, being blinded as well as the former.† The works of actual attack bore no proportion to the auxiliary lines of circumvallation. On these vast labour was expended. Those of the Princes of Orange we find fraised and palisadoed, with imposing relief and double ditches, and flanked at intervals, not by mere redans, but by bastioned forts, hornworks, and crownworks.‡ It seems to have been usual partially to employ the peasantry on these works; at the first investment they were set in large numbers to dig a ditch roughly marked out round the place,§ and meantime the engineers traced the elaborate niceties of the proper circumvallation within.

* See plate III., which is a facsimile of the original engraving to be found in a narrative of the siege written by the Dutch historian Daniel Heinsius. *Rerum ad Sylvam-Ducis atque alibi in Belgio aut a Belgis anno* MDCXXIX. *gestarum Historia. Lugduni Batavorum, ex officinâ Elzeviriorum*, MDCXXXI.

The *Vinea*, or sap here exhibited is stated by Heinsius to have been then employed for the first time, and to have been called *Porciana* after the inventor. But the country or vernacular name of this ancient Jebb does not appear.

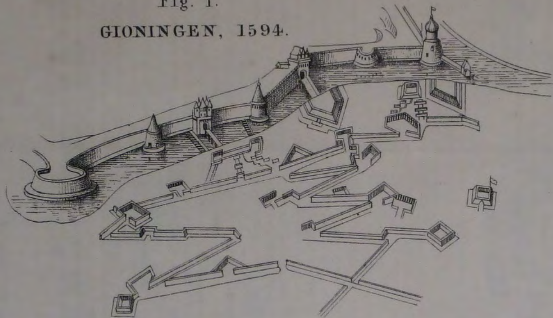
The single tier of gabions which seems to form the whole parapet of the sap in this case must have been some six feet high. Indeed gabions as large as, or larger than our present saprollers were commonly used, especially in batteries during the sixteenth, seventeenth, and beginning of the eighteenth centuries. Maggi (*Fort. delle Città* iii. 25.), speaks of the French at an attack of Perpignan using a double row of gabions, six feet in diameter and eight feet high. Sir Francis Vere (*Commentaries*, p. 14), describes a Spanish field-fort which he assaulted in 1590, as "reared of a good height with earth, and then with gabions set thereon of six foot high." In most of the prints of sieges during the seventeenth century, and in as late a work as the *Military History of Eugene and Marlborough*, 1736, one finds all batteries represented as formed of these large gabions, generally one to each merlon. See for example the lofty batteries illustrated in fig. 2, plate II.

† These galleries and similar works were frequently executed on contract by the Engineers, who seem to have borne all risks of damage by the enemy. "That same night," says Lithgow, in his *Experimental Discourse of this Last Siege of Breda* (1637) "the Scots began their gallery whereof one James Lecky was chief workmaster who was to have for perfecting the same 36,000 gilders." In the same siege (where the English, Scotch, and French auxiliaries each carried on an independent attack) the price of the English gallery was fixed at 17,000 florins, that of the French at 16,000. Should the work be finished before the appointed day the engineer was to receive a bonus of 600 florins per day for each day up to the fourteenth, but should it be destroyed by the enemy he was bound to restore it, and should the gallery not be ready by the fixed period he was to forfeit 2000 florins. These details are from a Latin narrative of the siege by M. Z. Boxhorn. At Groll, in 1627, where also English and French are found working in rivalry, a bonus of 4000 livres was promised to the party which should first finish their gallery. The English gallery having been twice burnt by the enemy the French gained the prize, but our countrymen succeeding in first effecting a lodgment on the ramparts of the place were handsomely rewarded by *Messeigneurs les Etats.—Hist. de la Vie et Actes memorables de Frédéric Henri de Nassau, Amsterdam*, 1656.

‡ Frederic Henry's double lines round Breda each exceeded 18 miles in extent, "by which," Lithgow says, "Breda stood in the centre like a maypole in a market-place, or like to a theefe in a common hall condemned to die." Spinola's circumvallation of the same city (1625) had 52 miles of parapet, the contravallation 16 miles, flanked by 96 redoubts, 37 forts, and 45 batteries. At Bois-le-Duc (1629), the entire extent of Frederic Henry's works was nearly 70 miles.

§ Till about the period referred to siege trenches appear to have been generally executed by labourers pressed from the surrounding districts, or by bands of professed pioneers (called by the Italian writers *guastatores*), who accompanied the army. At Gertruydenberg, in 1593, Prince Maurice appears to have introduced the practice of making the troops handle the spade and pick with extra working pay, according to our present system. Thirty years before we find Maggi (*Discourse on Field Entrenchments*), recommending that those of the soldiers who were not *ashamed* should work, according to the practice of the ancients; evidently not considering it binding on a soldier. "Les Espagnols," says Antony Deville, "ne veulent jamais faire aucun travail; ils estiment que cela est indigne de leur grandeur."

Fig. 1.
GIONINGEN, 1594.



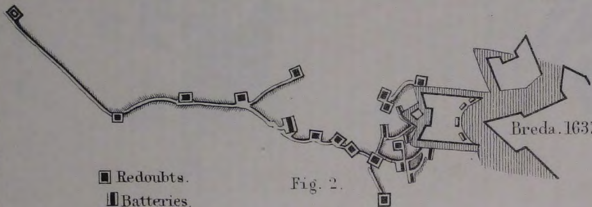



Fig. 2.

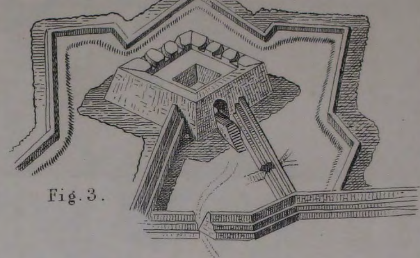


Fig. 3.

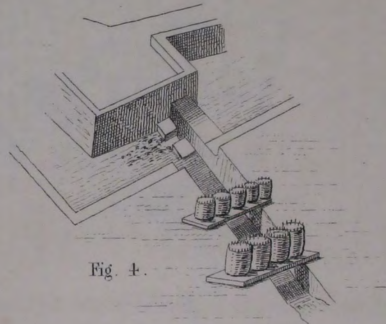


Fig. 4.

J. R. Jobbins.

Fig. 1.

*Part of the Turkish Attack on Vienna in 1683.*
*From a Contemporary Print.*

Fig. 2.

*"Mounts for Shot"*
*(From the Siege of Grave by the Prince of Parma in 1586)*

J.R. Jobbins.

The Turks, who, like other half-barbarous nations of the East, had an instinctive skill in works of intrenchment, as well as vast armies to carry them out, had long been in the habit of employing zigzags, or at least winding, excavations of approach, and extended trenches parallel to the besieged fortress, as places of arms for the support of the attack. These latter were sometimes multiplied to an enormous extent, as at Candia (1669), and at their memorable attack on Vienna, in 1683.*

Probably Vauban took from the former siege, with the circumstances of which he must have been familiar, aided as the garrison had been by French detachments, the hint of the extensive parallels which he employed with such complete success at Maestricht, in 1673.† These he continued to improve and methodise, combining with them zigzag approaches on the capitals, the systematic use of vertical fire, trench cavaliers to drive the defenders from the covered way (first used at Luxemburg in 1684); and, finally, with ricochet (introduced at Philipsburg in 1688, matured at Ath in 1696), which perfected his system of attack.

And at Breda even, where their regular wages were long in arrears, whilst the working Pay was distributed daily to those who volunteered to labour in the trenches, many "preferred to preserve their dignity in hunger and beggary, to obtaining a livelihood by honest labour."—*Hugo—Obsidio Bredana*, p. 32. Though two centuries ago General Monk laid down the maxim, that "soldiers ought to know that when occasion requireth them to intrench themselves, it doth as properly belong to their duty to intrench themselves as to stand centry or carry their arms," we still find something of the Spanish sentiment among our own troops when called on to handle the spade. And in the Sepoy army the sentiment is not only felt but indulged by the authorities. Father Daniel, quoting Montluc, mentions that marshal as having employed his troops on intrenchments in blockading Boulogne, and that other soldiers used to abuse them as they returned from their work. At the siege of Amiens (1597) Henri IV. made his men work in the trenches, paying them per toise, and allowing survivors the wages of those who fell. Louis XIII. at St. Jean d'Angely did the same.—*Daniel, Hist. de la Milice Françoise.*

* Fig. 1, Plate II., illustrates the Turkish mode of attack. It is an extract from a large print containing a bird's-eye view of the whole besieged city of Vienna, published at Amsterdam soon after the event.

† On the siege of Maestricht, Sir J. C. Smyth, R.E., (in his *Epitome of the Wars in the Low Countries*, p. 34), has the following remarks:—"This siege is remarkable for being the first at which European armies made use of the zigzags, or the present mode of tracing approaches in attacking a fortified place. They were introduced by Vauban, who borrowed them from the Turks. It is generally believed that parallels were first employed at this siege; but this is a mistake, and Vauban's talents and skill do not require any erroneous statements to give them a false glare. Trenches to contain the assailants had been excavated parallel to the works of the fortress to be attacked, from the earliest times. Vauban's improvement consisted in tracing the approach or communication from the parallel, so that it should not be enfiladed, and which the Turks had done long before."

There can be little difficulty in showing that the "general belief" is substantially correct, and that both the statements in this passage are erroneous.

An inspection of our fig. 1, Plate I., is sufficient to prove that zigzags of approach were used in European armies long before Vauban was born, and a dozen other instances might be adduced.

With regard to the other point we know (*Daniel*, i. 568) that short parallel returns to contain the guards of trenches were introduced by the celebrated Blaise de Montluc, at the siege of Thionville, in 1558; and that extensive parallels also are occasionally met with previous to the siege of Maestricht. For example, in the plan of the attack on Edinburgh Castle, when held by Kirkaldy of Grange, in 1573, the batteries are established in a first parallel encircling the castle, and there is a distinct indication of a second in advance, from which musketeers are firing on the defences. But the importance of these parallels was not appreciated; they formed no part of the regular system of attack, and were more generally omitted; great pains being taken in fortifying the batteries themselves against sorties, to which they were so much exposed from this want of extended protection on the flanks. Louis XIV. himself, who was present at Maestricht, speaks of Vauban's parallels as entirely new. "We advanced," he says, "against the place, as if in line of battle, with great and spacious parallel trenches, from which the troops, issuing by means of the banquettes which lined them, could meet the enemy on an extended front. The Governor *had seen nothing like this before, although he had been in five or six besieged places.* On those occasions the trenches had always been so contracted that it was impossible to make head against the most trifling sortie."

# PAPER VIII.

## MEMORANDA ON THE USE OF ASPHALTE. Communicated by COL. OLDFIELD, Royal Engineers.

HAVING heard and read much of the efficiency of the Seyssel asphalte in covering arches, as well as its utility for other purposes, I was disposed to test its qualities, and consequently obtained the sanction of the Master-General and Board to introduce it, in my command in the Canadas, by covering the terreplein of the ramparts, at Fort Henry, over the casemates, the arches of which were not impervious to the wet.

The materials, with the necessary implements for working them, were sent from England, as also a person experienced in the use of asphalte, to superintend its application; it was laid on early in the autumn of 1842, but, exposed to the frost, it was a failure. Had I remained in Canada, I had proposed to test it the following year, by removing the soil over the arches, covering the arches with the asphalte, and then replacing the soil, much in the way I have since proceeded at Plymouth.

In the year 1846, it was decided to restore, for the occupation of troops and stores, the casemates in the citadel of Plymouth: platforms were to be laid in Cumberland Battery, for the heavy armament recommended by the committee on the Harbour Defences, in 1844, and the Master-General and Board (to avoid the necessity of disturbing, in the succeeding years, the platforms about to be laid) authorised the casemates on this front to be at once proceeded with. The restoring the casemates commenced on the 1st of June 1846, and they were in a state for occupation on the 26th of February, 1847. The estimated cost was 2365*l.* 5*s.* 7¼*d.*: the actual cost, 2,156*l.* 13*s.* 0¼*d.*

The number of casemates restored, ten.

The accommodation gained, eighty-three non-commissioned officers and men, with a guard-room and artillery store.

Although previously uninhabitable from damp, they have since their completion been almost constantly occupied, and not a drop of water has been admitted through the arches; in fact, the asphalte, as a covering to the arches, has in this case completely succeeded. During the working season of 1847-8, the rest of the casemates, twenty-five in number, with two magazines, a guard-room and artillery store, have been covered in like manner, and as far as yet known, with equal success.

The floors also, in asphalte, have not sustained injury from the barrack bedsteads or furniture; they are impervious to wet, and consequently require that all water spilt on them should be immediately mopped up.

Asphalte was used as a coping to the top of the parapet of Cumberland Battery, on concrete, upon rubble; the fillets were of cement; the heavy frost of 1846-7 destroyed the cement; the wind had access and broke away the asphalte; it was restored with brick at the outer and inner edges, and has not only withstood the winter, but the concussion from the fire of six rounds of a thirty-two-pounder, fired successively.

The efficiency of asphalte, as far as I had tested it in the citadel, and the failing of the masonry embrasures, into which the morning and evening gun had been in succession removed, upon the old saluting battery being armed with heavy ordnance, induced me to suggest the adoption of asphalted brickwork in the construction of an embrasure: its efficiency, as far as the test has gone, has been complete; the morning and evening gun has been fired daily since the afternoon of its completion, except during the two or three days when a thirty-two-pounder was run into it, to try the effect of its fire with a service charge; the report of this test is annexed, as also that of four other embrasures of different construction.

The charge made by the Asphalte Company for the construction of the embrasure was 66*l.*; the cost, had it been in granite, in block, according to the schedule prices—

| | £. | s. | d. |
|---|---|---|---|
| At Plymouth would be . . . . . . . | 71 | 4 | $7\frac{3}{4}$ |
| In lime-stone in block . . . . . . | 63 | 19 | 9 |
| Brickwork in cement . . . . . . . | 33 | 3 | $2\frac{1}{4}$ |
| Brickwork in mortar . . . . . . | 26 | 10 | $2\frac{1}{2}$ |
| Limestone rubble masonry in courses scabbled on exterior face . . . . . . . | 26 | 18 | $8\frac{1}{4}$ |

I think it probable that an embrasure built with bricks, of the very best quality set in, but not covered with asphalte, might prove equally efficient, at a less cost, and is at all events worth the test.

During the last season asphalte has been used in covering arches and towers at Staddon Point Battery.

At the buildings connected with the battery at Picklecombe Point, it has, as far as we can yet judge, proved efficient.

Asphalte apparently adheres well to brick and wood; of the latter there is a case in point in the pump-trough in the lower fort of the citadel; the wood trough was asphalted in June, 1847. The pump has since that been in constant use by a garrison averaging, say 600 men, without the slightest damage. To masonry and iron it has failed to adhere.

From what I have seen of the use of the Seyssel asphalte, I am of opinion that, if the *materials and workmanship are unexceptionable,* it is most efficient for the covering of arches, and the floors of tanks, ablution rooms, stores, and many other barrack buildings; but that the slightest deficiency in workmanship or materials will cause a failure.

The efficiency of asphalte should be severely tested in every possible way before it is extensively adopted in the service.

J. OLDFIELD,
Colonel Royal Engineers.

*24th March,* 1848.

*(Copy.)*

REPORT OF TESTS OF EMBRASURES IN PLYMOUTH CITADEL, JAN. 24, AND ST. NICHOLAS ISLAND, FEB. 2, 1848, IN REFERENCE TO M. G. & B. O. OF JAN. 14, 1848, E 41, FORWARDED WITH INSPECTOR GENERAL OF FORTIFICATIONS' MINUTE OF JAN. 17, 1848.

## PLYMOUTH CITADEL.

| No. of Test. | From whence. | Construction of Embrasure. | Nature of Gun. | Charge. | Effect on Embrasure. | Remarks. |
|---|---|---|---|---|---|---|
| 1 | No. 2 Embrasure, Cumberland Battery. | The thickness of the parapet (at the embrasure fired through) is 6 ft. 5 in., exterior opening 7 ft. 9½ in., and interior opening 3 ft. The cheeks and sole of the embrasure, as well as the merlons, are formed of common rubble masonry, the tops of the merlons being covered with asphalte on concrete, and a row of asphalted brickwork half-brick thick on top of each cheek; the sides of the embrasure are pointed with Roman cement. | 32-pr. | Service. | The first fire shook the outer part of sole of embrasure, the second increased the damage and blew out the centre front stone, which was about 3 in. thick.<br>The damage to the sole increased with every fire; when, after the sixth, about one half of the sole was much injured, the top stones (about 3 in. thick) being shaken off. The front top quoin stones of both cheeks of embrasures appeared to be a little disturbed on the third fire, and after the sixth fire were much shaken, and the pointing in cement of a considerable portion of each face cracked.<br>The merlons were not injured, and thin coatings of asphalte at their top, and the asphalted brickwork, only half-brick thick, on top of each cheek, were not in the least degree cracked. | |

*Inspector General of Fortifications.*

| No. of Test. | From whence. | Construction of Embrasure. | Nature of Gun. | Charge. | Effect on Embrasure. | Remarks. |
|---|---|---|---|---|---|---|
| 2 | Right flank of Old Saluting Battery. | The thickness of the parapet (at the embrasure fired through) is 6 ft. 2 in., exterior opening 6 ft. 7 in., and interior opening 3 ft., with throat only 2 ft. The sole and cheeks of the embrasure are formed of asphalted brickwork, the sole being one brick thick laid on concrete, and the cheeks two bricks thick, with counterforts (as they may be termed) 1 ft. 6 in., and adjoining the merlons, which merlons are of rubble masonry (see plate). | 32-pr. | Service. | This embrasure sustained no injury whatever from the six rounds fired through it. The portions of the merlons of rubble masonry adjoining the asphalted brickwork appeared to heave up on each fire, and are much shaken by the explosions. The sod-work on the top of the cheeks of the adjoining embrasure was shaken. | |
| 3 | Left flank of Old Saluting Battery. | The thickness of the parapet (at the embrasure fired through) is 6 ft. 6 in., exterior opening 8 ft. 2 in., and interior opening 2 ft. 6 in., with throat only 2 ft. Sole of granite blocks, cheeks of limestone in block or ashlar work with the stones dowelled into each other.<br><br>The merlons of rubble masonry. | 32-pr. | Service. | On the first fire the outer stones of right cheek of embrasure sustained a shake; the second fire increased it; and so on till the sixth round, when it appeared that all the blocks of stones were considerably shaken, but still retained their places. Had not the blocks of stone been dowelled into each other, some of them would in all probability have been displaced and thrown down. The sole of embrasure is slightly shaken at the first cross joint.<br><br>The merlons are a good deal shaken to 3 or 4 ft. on each side of the cheeks of embrasure. | |

## ST. NICHOLAS ISLAND.

| No. of Test. | From whence. | Construction of Embrasure. | Nature of Gun. | Charge. | Effect on Embrasure. | Remarks. |
|---|---|---|---|---|---|---|
| 1 | Battery. | The thickness of the parapet of the embrasure fired through is 6 ft. 8 in. at top, and 9 ft. 11 in. at sole, exterior opening 12 ft. 6 in. Interior opening 4 ft., with throat 3 ft. 2 in. Sole of embrasure formed of large blocks of limestone, about 1 ft. 6 in. thick, dowelled at the meeting-joints. Cheeks of limestone in large blocks, dowelled into cheek stones. Merlons of limestone rubble masonry under coping of 1 ft. thick. | 8 inch shell gun on dwarf traversing platform. | Service. | The explosion from the first fire produced no injury.<br>Do. from second fire disturbed a little pointing of right cheeks, muzzle of gun pretty close to right cheek.<br>Do. third fire further disturbed the pointing.<br>Do. fourth fire still further disturbed the pointing, and shook out much of the pointing of the sole<br>Do. fifth fire produced but trifling shake of pointing, muzzle of gun pretty close to left cheek.<br>Do. sixth fire produced still further shaking of pointing, muzzle of gun do. do.<br>From the six explosions the merlons received no injury whatever. | The pointing had previously suffered injury from the recent frosts preceded by heavy rains. |
| 2 | Battery. | The thickness of the parapet of the embrasure fired through is 19 ft. 8 in. at sole. Exterior opening 9 ft. $1\frac{1}{2}$ in. Interior opening 2ft. 6 in., with throat 1 ft. 10 in. Sole of embrasure formed of sod-work. Cheeks and merlons of brick, covered with sod-work about 2 ft. 3 in. thick. | 32-pr. on common wooden garrison carriage. | Service. | The explosion from the first fire caused no damage, muzzle of gun pretty close to right cheek.<br>Do. second fire, do. do.<br>Do. third, fourth, and fifth fires, do. do.<br>Do. sixth fire a portion of the brickwork of right cheek, at about 2 ft. 6 in. from throat was cracked, but the bricks retained their position.<br>The merlons were not injured by the six explosions, and the granite platform, 12 ft. 11 in. broad, with slope of $1\frac{1}{2}$ in. to 1 ft., was not disturbed further than the pointing under the gun being blown out. | |

*February* 9, 1848.

(Signed) J. OLDFIELD,
Colonel Commanding Royal Engineers, Western District.

DETAIL OF WORK REQUIRED ON INSPECTION AT PLYMOUTH CITADEL,

| What part of the Works. | Description of Workmanship and Materials. | No. | Dimensions. Length. | Width. | Depth or Thickness. | Contents. | Price. | Data and Remarks. Here insert any remarks that may be necessary, and especially as to the price, whether it be an agreed or contract price; and if not, give the analysis of how it is made up. |
|---|---|---|---|---|---|---|---|---|
| Right Flank of Old Saluting Battery. | CONSTRUCTING ASPHALTED BRICK EMBRASURE. | | | | | | | £ s. d. |
| | Asphalte layers ....................days | 28½ | ... | ... | ... | ... | 4s. 6d. | 6 8 3 |
| | Ditto, 2nd class .................... „ | 53 | ... | ... | ... | ... | 3s. 6d. | 9 5 6 |
| | Cauldron men.................... „ | 50 | ... | ... | ... | ... | 2s. 4d. | 5 16 8 |
| | Asphalte ....................tons | 2¾ | ... | ... | ... | ... | 8l. | 22 0 0 |
| | Mineral pitch ....................cwt. | 2 | ... | ... | ... | ... | 1l. | 2 0 0 |
| | About 1½ ton of Coke and ½ ton of wood ...... | ... | ... | ... | ... | ... | 1l. 10s | 1 10 0 |
| | | | | | | | | 47 0 5 |
| | Bricks .................... | 2700 | ... | ... | ... | ... | 60s. | 8 2 0 |
| | Lime .................... bushels | 20 | ... | ... | ... | ... | 5½d. | 0 9 2 |
| | Sand .................... „ | 60 | ... | ... | ... | ... | 2½d. | 0 10 0 |
| | Cement .................... „ | 3 | ... | ... | ... | ... | 3s. 9d. | 0 11 3 |
| | Masonry and labour ....................days | 18 | ... | ... | ... | ... | 5s. 9d. | 5 3 6 |
| | | | | | | | | 14 15 11 |
| | Deduct 6 per cent. .................... | ... | ... | ... | ... | ... | ... | 0 17 9 |
| | | | | | | | | 13 18 2 |

DETAIL OF WORK, &c. (*continued*).

| What part of the Works. | Description of Workmanship and Materials. | No. | Dimensions. Length. | Width. | Depth or Thickness. | Contents. | Price. | Data and Remarks. |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | £ *s.* *d.* |
| Right Flank of Old Saluting Battery. | Carpenter | 3 | ... | ... | ... | ... | 3*s.* | 0 9 0 |
| | ½ Deal ... feet | 10 | ... | ... | ... | ... | 2*d.* | 0 1 8 |
| | Nails, Clout, &c. | 250 | ... | ... | ... | ... | 4*d.* | 0 0 10 |
| | | | | | | | | £0 11 6 |
| | Total cost, *without profit*, on *Asphalte Work*— | | | | | | | |
| | Asphalte Work | ... | ... | ... | ... | ... | ... | 47 0 5 |
| | Masons' ditto | ... | ... | ... | ... | ... | ... | 13 18 2 |
| | Carpenters' ditto | ... | ... | ... | ... | ... | ... | 0 11 6 |
| | Total | ... | ... | ... | ... | ... | ... | £61 10 1 |

*Feb.* 1848.

J. W. SHINAS,
*Clerk of Works.*

The work commenced, Jan. 22, 1847; completed, Dec. 14, 1847; the gun replaced in the embrasure that evening, and daily fired as the morning and evening gun. The embrasure tested Jan. 24, 1848, by six rounds from a 32-pr. gun: rounds 1 and 2 along the curtain of the embrasure, 3 to 6 sharp to the right, depression as much as could be given. No injury whatever sustained by the embrasure; the masonry beyond it slightly but perceptibly disturbed.

ROYAL ENGINEERS' OFFICE,
DEVONPORT, *July* 4, 1840.

Description of the manner in which the casemates at Plymouth Citadel were rendered dry by the application of Claridge's Seyssel asphalte as approved by the Board's order, 25th May, 1846, $\frac{A}{174}$ with expense, time of execution; and report upon its efficiency up to the present time, accompanied by an explanatory plan, as called for by the I. G. F.'s note of the 3rd May, 1849:—

The rubbish forming the solid parapet and filling-in over the arches having been removed, about one-half of the dos d'âne were found covered with strong rag slate bedded in mortar, quite decayed; sunk half-circular drains were formed between in Purbeck stone to lead the water that soaks through the filling-in to the water trunks.

The remaining portion of the dos d'âne over the arches were covered with clay, about six inches thick; drains formed between as before described, and the whole surface over the clay was covered with coarse shingle or pebbles, averaging from four to six inches thick; these coverings were removed from over six or eight casements at one time, down to the solid masonry which formed the dos d'âne of the arches.

The whole mass of masonry was thoroughly saturated with water.

The masonry was exposed to the sun to dry for several weeks previous to filling in the rubble masonry and concrete to form the proper slope for the covering of Seyssel asphalte.

Ventilator flues, &c., from the casemates were cut out and formed in the solid masonry of the parapet, as shown in transverse and longitudinal sections.

The steep slopes of the dos d'ânes were reduced by filling-up between with rubble masonry, built in Plymouth lime and sand-mortar well grouted, marked *a a a a a*, in longitudinal section: where the masonry got sufficiently dry a coat of concrete six inches thick was laid on over the whole surface, properly floated to receive asphalte.

The concrete was composed of five-sixth shingle and coarse sand, and one-sixth ground Aberthaw lime properly mixed together.

When this concrete had become thoroughly dry the asphalte was laid on in two coats, *each* about three-eighths of an inch thick and from two and a half to three feet wide; the upper coat breaking joint over the lower; these two coats being united into one solid body by the heated state of the asphalte at the time it was laid, marked *c c c c c*, on longitudinal section.

A cast-iron gutter marked *k* on transverse section, seven inches diameter, three-eighths of an inch thick, coated inside with fluid asphalte firmly built in the masonry of the front wall, and connected with the asphalte coating over the dos d'âne and between the arches, and the asphalted brick lining up the walls to convey the water that may soak through the filling-in from the brick drains to the water trunks.

The bricks for the asphalted brickwork were sound hard-burnt and perfectly dry (those of a rough sand surface are to be preferred).

The bricks for this work were prepared in the following manner: a common wood bench about ten or twelve feet long, from four to five feet wide and about three feet high, placed in a dry store, a frame of deal one and a half inch thick, from eight to ten feet long; the sides were half an inch higher than the bricks when placed edgewise in the frame; the dust was well brushed off the bricks; a coat of hot fluid asphalte was laid on over the whole surface of the bricks between the two sides of the frame, floated over, leaving a covering of asphalte about half an inch thick on the edge of the bricks; one side of the frame being removed, the coating of asphalte was cut through and the bricks removed separately and either stacked, or carried at once to the place where the work was in progress; the first course of bricks were laid in the hot fluid asphalte on the coating of asphalte over the arches, and each brick bedded and jointed separately in hot fluid asphalte, the full width of the brick throughout the whole work; the coating of asphalte on the edge of the bricks being united by the hot asphalte in bedding and cross-jointing the bricks in each course, the joints were flat drawn during the heated state of the asphalte—forming one solid and smooth surface.

The asphalted brickwork is continued up to the height of the grooves shown in transverse section, finished by a slope formed in concrete on the last course of bricks, which is covered with asphalte from the face of the brickwork to the back of the groove formed in the masonry, shown in transverse section marked *i i*.

The vacuity between the back of the asphalted brickwork and masonry of the parapet being flushed up with good common mortar and small chippings of bricks.

The asphalted bricks in the grooves are finished with a gutted surface and a fillet of asphalte stopping toward the outer edge of the bricks; the masonry over being set and pointed with cement, marked *f f f f f*.

Brick drains five inches square are formed between the spandrils of the arches; shown in longitudinal and transverse sections, set in asphalte and covered with a brick on flat, leaving an opening of one inch between the butting ends of each brick, to give full effect to the drainage, from the filling-in through the shingle and rubble stone. These drains are covered over with rubble stone laid in dry round the sides and over the tops, and a layer of coarse shingle or pebbles from four to six inches thick over the rubble stone, to allow free percolation and to prevent the filling-in from choking the drains. The space between the parapets is filled in with rubbish to the proper level, leaving the asphalted brickwork to appear in the grooves six inches above the finish level on each side, shown in transverse section, marked *f f*.

The superior slope of the parapet is also covered with Seyssel asphalte, laid five-eighths to three-fourths of an inch thick in two coats, broken-jointed, on concrete three inches thick, and floated as before described; the out and inside edges are finished with a course of bricks laid on flat in cement, bedded and jointed with asphalte, and finished with an asphalted gritted surface, the coating on the slope being connected with the brickwork, prevents leakage and secures the asphalte to the parapet.

The whole of the casemates are covered and finished in the manner described and shown in plan and sections forwarded.

Ten casemates under the Cumberland Battery were commenced on the 1st June, 1846, and completed the 14th February, 1847.

The remainder of the casemates were commenced on the 1st March, 1847, and completed the 12th February, 1848.

The total expense of covering these casemates amounted to £8265 3*s.* 3¼*d.*

The *Seyssel asphalte* covering has rendered the whole of the *casemates* and *arches perfectly dry;* not the *slightest failure* or *damp* can now be *traced* throughout the whole of the interior. They have been generally occupied by troops since the completion of the work.

(Signed) F. W. SHINAS,
Clerk of Works.

*July* 3, 1849.

THOS. H. RIMINGTON,
Captain Commanding Royal Engineers.

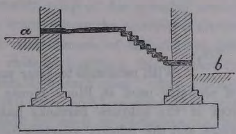
*July* 4, 1849.

---

ROYAL ENGINEERS' OFFICE,
PORTSMOUTH, *March* 31, 1848.

SIR,—

In reporting on my experience of Seyssel asphalte as a material for building purposes, I beg to state it is rather limited, as far as my own superintendence is concerned, it being confined to the several small buildings and officers' quarters at the Round Tower Fort, where it is used as a material for roofing and floors; it is also introduced in the footings, one course above the ground level, to prevent the rising of *damp*, in which latter case I am convinced of its great utility; great care should be taken to ensure its efficiency where sloping ground is to be built on, or where the footings are steepened, to connect the asphalte. The annexed sketch will convey the plan adopted at those buildings before referred to, where the street and parade levels were very different.



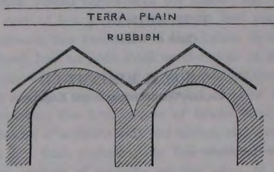

*a* Parade Level. *b* Street Level.

In its adaptation as flooring, I think it should be limited to buildings such as store-rooms, cooking and washing houses, and other buildings, where a *cold* damp surface is not very objectionable, but for living rooms, as soldiers' rooms, I think it most objectionable, and very unhealthy, it always during a damp, humid, atmosphere, presenting a moist surface, from its non-absorbing quality.

As a material for roofing it is very difficult to give an opinion from its recent introduction; I should, however, think it rather objectionable, without further trial, for very large framed roofs, where there is great liability to shrink and expand in the timbers, and from observation I think it has not sufficient elasticity to resist that liability.

There are very many purposes in the service of the department where it may be advantageously applied, such as covering the arches of casemated batteries and barracks, also arches of magazines and other buildings constructed of material not liable to the previous objections.

From observations made during a visit to Plymouth in July last (during my leave of absence), I saw the material (asphalte) used with great advantage in covering the arches of old casemates in the citadel of that place, which were always very *damp;* the ground was taken out and spandrils of the arches cleared, leaving the arches bare, on which was laid a slight thickness of concrete, and on which was laid a coating of asphalte. The annexed rough sketch from memory will convey some idea: the walls were lined with asphalted brick work from the arches nearly up to the parapet, the asphalted bricks were put together in patches of about three bricks in length, and four courses in height, which admitted of great dispatch and greater efficiency; the asphalte was laid in a sloping direction to carry off the water that may filter through the earth above, which met and formed itself into a drain to lead it away. I saw some of the casemates which had been served in the manner described, then in occupation as soldiers' rooms, and it was found to have had the desired effect.




But from the little experience I have had of the material, I find a difficulty in reporting very favourably for its extensive use in exposed situations.

I have the honour to be, Sir,
Your most obedient humble servant,
CHARLES GOODYEAR,
Foreman of Works.

COL. LEWIS, C.B.
Commanding Royal Engineers, Portsmouth.

---

GOSPORT, *March* 29, 1848.

SIR,—

With reference to your memorandum of the 26th inst., on the subject of asphalte used at Block House Fort, I have the honour to state that the roof of the soldiers' barracks has been covered with asphalte for about two years, and the officers' quarters for a year and a half, and that it has proved an efficient and perfectly dry covering, no water having been admitted by the roof at any time, or in any part, in either of these buildings.

The platform of the new bastion has been covered with the same material for nearly a year, and with the same successful result.

I have the honour to be, Sir,
Your most obedient servant,
J. S. SERVANTE,
Capt. R.E.

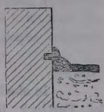
COL. LEWIS, C.B.
Commanding Royal Engineers, &c. &c.

---

ROYAL ENGINEERS' OFFICE,
PORTSMOUTH, *March* 30, 1848.

SIR,—

In reporting on the Seyssel asphalte, which has come under my immediate superintendence in the Royal Engineer Department, I beg to say the quantity is very limited, viz., covering a portion of the main arch at King William's Gateway, covering two expense magazines, and soles to four embrasures at the King's Bastion and Curtain.



A portion of the main arch at King William's Gateway was covered in 1846, with fine Seyssel asphalte, three quarters of an inch thick, and a skirting of the same run into a groove in the masonry, cut for that purpose (see marginal sketch).

The covering answers very well with the exception of the skirting, which I found on close examination this morning is drawn slightly off in places from the masonry, and on pouring water into the interstices found it gradually diminish, and in a few seconds disappear.

The roof of the first magazine in the Curtain was covered with fine Seyssel asphalte, five-eighths of an inch thick, with a fillet of the same material under each joint as a precaution against leakage at the joints (see marginal sketch).

The next done was soling four embrasures in the King's Bastion with coarse Seyssel asphalte, averaging one inch in thickness, two of which were blown over into the bastion by the wind; the other two were removed by order of Colonel Lewis.

The second magazine in the curtain was covered with the asphalte that came from the soles of the embrasures, with the addition of a small quantity of the fine material laid on in two half-inch thicknesses, taking care to break joint with the second course. The two thicknesses were thought necessary as the material was of the coarser quality, and better adapted for paving than roofing.

I consider the fine Seyssel asphalte admirably adapted for covering arches or roofs of magazines, as being impervious to water, where the material is always covered with earth, &c., and not exposed to the changes of the climate, but where asphalte is exposed, such as on wood roofs of buildings, the contraction and expansion of the material must be considerable in such cases: when exposed due allowance should be made for the two extremes, and I would suggest that lead flushing to parapets and chimneys should be used in preference to the asphalte skirting now adopted.

The coarse Seyssel asphalte is well adapted for street pavement, floors to kitchens, washing-houses, &c., where the contraction, &c., of the material is of little consequence, but for floors of sleeping apartments I should not recommend it, being always damp and wet when the atmosphere is moist; the asphalte, being less porous than brick or wood, causes the moist air to become condensed, and I have seen floors of asphalte streaming with water in damp weather.

I am, sir, your most obedient humble servant,

GEORGE FABIAN,
Foreman of Works.

To Col. Lewis, C.B.,
Commanding Royal Engineers, &c., Portsmouth.

Royal Engineers' Office,
Portsmouth, *March* 30, 1848.

Sir,—

In obedience to your order of yesterday, communicated to me by Lieut.-Col. Portlock, R.E., respecting my experience or knowledge of the qualities of the Seyssel asphalte (Claridge's patent), I have the honour to report that the undermentioned services under my notice have been performed :—

| | Remarks. |
|---|---|
| Colewort Barracks, bedding store. Roof covered with asphalte about two years and three quarters. | No appearance of leakage. |
| Colewort Barracks' cookhouse. Pavement in front laid about two years. | Appears to wear well. |
| Ordnance Hospital. Kitchen floor laid about ten months. | Wears well. |
| Cambridge Barracks. Pavement in front of guard house laid about three years. | Wears well. |
| Women's washing house. Floor laid about eight months. | Wears well. |
| Portsea officers' barracks. The roof covered about nine months. | No appearance of leakage. |
| The pavement in front laid about six months. | Stands well. |
| Layer of asphalte above ground line, laid about fourteen months. | Appears to keep the damp from rising. |
| Kitchen floors laid about ten months. | Stands well. |

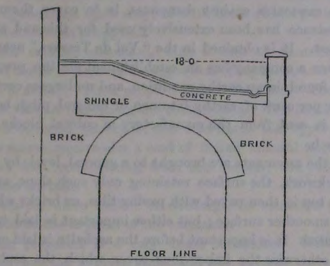
From my observation of the material in question, it appears well adapted for the purposes for which it has been applied.

I have the honour to be, Sir,
Your most obedient humble servant,

JOHN EVANS,
Foreman of Works.

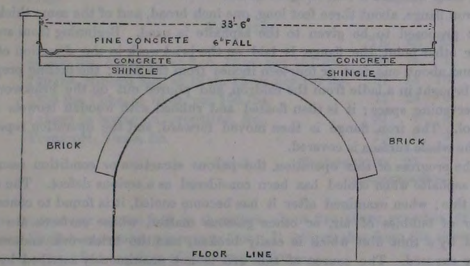
Col. Lewis, C.B.,
Commanding Royal Engineers, Portsmouth.

The officers' quarters and soldiers' barracks at Block House Fort; the brick spandrels are carried up to within one foot of the crown of the arch, and the remainder with shingle, and the surface formed with a bed of coarse concrete




Section of Officers' Quarters, Block House Fort.

1 foot in thickness, with a fall of $1\frac{3}{4}$ inch in ten feet towards the front, and then a bed of fine concrete $1\frac{1}{4}$ inch thick, and floated smooth to receive the asphalte. The asphalte is prepared by boiling with a portion of tar, and stirred until properly incorporated, and poured on in a liquid state, and troweled with wooden floats until thoroughly set, and then fine grits rubbed over to give it a smooth surface.




Section of Soldiers' Barracks.

The ingredients for the officers' quarters and soldiers' barracks were $2\frac{1}{4}$lb. of Stockholm tar to 1 cwt. of Asphalte without grit.

For the New Bastion, $2\frac{1}{2}$lb. of tar and 12lb. of grit*, to 1 cwt. of Asphalte.

The whole of the buildings were covered $\frac{5}{8}$ in. thick.

J. HAMMOND,
Foreman of Works.

* 17lb. of grit is now substituted, by which a firmer consistence is given to the asphalte.

### Means against Damp in Casemates.

The system now pursued in the engineer department at Köln, with the view of guarding the casemates against dampness, is to cover them with asphalte. This mineral substance has been extensively used for this and similar purposes for some years past. It is obtained in the "Val de Travers," near Neufchatel, in Switzerland, where a company has an establishment for the preparation of this material. It is found in an earthy condition, and undergoes certain processes to fit it for use, four per cent. of earthy bitumen or mineral pitch being added to it at this time. It is sent from the manufactory in cubical blocks, weighing from 300 to 400 lbs. each.

The arches of the casements are brought to a general level, by filling in of the valleys with brickwork, the surface retaining only such slope as is sufficient to current it. The top is then paved with paving tiles, or bricks which are rubbed to give them a smoother surface; but either important is laid in Trass current, and carefully pointed. It is important before the asphalte is laid on the brickwork should be dry; otherwise the impervious cover which the asphalte forms will retain the moisture in the masonry, without its being able to escape.

An iron tripod, carrying a furnace and kettle, is brought to the spot where the work is to be executed; the asphalte being cut into pieces about two inches square is then put into the kettle, together with another proportion of six per cent. of mineral pitch, and the mass is heated and stirred up till it becomes fluid and boils. The proportion of mineral pitch, therefore, amounts to ten per cent. The mineral pitch gives to the asphalte a greater fluidity. The time required for boiling takes two and a half or three hours.

An iron flange, about three feet long, one inch broad, and of the same thickness as that proposed to be given to the asphalte is used. Beginning from an end wall or other point, the flange is laid on the brickwork in the direction of the slope, and about one foot or fourteen inches from the wall; the boiling preparation is brought in a ladle from the caldron, and poured out on the brickwork in the intervening space; it is then floated and rubbed with wooden trowels until it is cool. The iron flange is then moved forward, and the operation repeated until the whole surface is covered.

In the progress of this operation, the porous structure or condition assumed by the asphalte when cooled has been considered as a serious defect. The state of it is this; when examined after it has become cooled, it is found to contain a number of bubbles of air, or other gaseous matter, whose surfaces are only covered by a thin film which is easily broken, and the brickwork underneath thereby exposed. The source of this evil is not unanimously ascribed by the Prussian officers to the same cause. It is assumed that the air contained in the paving tiles being heated by the contact of the boiling asphalte expands, and, having no means of escape, forms through its expansive force the bladders and vesicles alluded to; or these defects may arise from some gases generated by the asphalte itself. In my opinion, it is occasioned by those changes in the bulk and structure in matter, which ever accompany a transition from a fluid to a solid state. In this way lavas are found which, not having cooled under pressure, have every degree of vesicularity from bladders the size of almonds to inconsiderable and imperceptible pores. It appears to me the most effectual remedy against the evil complained of (and it certainly is a very serious one), would be to subject the composition to as heavy a pressure as practicable while cooling, either by massive iron trowels, or rollers, which might yet be preferable.

It is usual, on the principal casemates, to place two coats of asphalte, each coat about one-eighth of an inch thick. In the first coat, all the bladders are looked for, and opened and again stopped with hot asphalte; when this has been completed, the second coat is applied.

In some of the smaller casemates, with a view to economy, the first coat consists of boiled mineral tar, with a proportion of asphalte, to which also a small quantity of lime is added. Their proportions are not fixed. The lime, I believe, is given with the view of hardening the composition. The latter is placed on the casemates with a common tar-brush, and afterwards the upper coat of asphalte is applied. The scarps receive also a coat of boiled mineral tar, and asphalte for a breadth of two feet, commencing from the cordon; the remaining surface is covered with Trass current.

The rear of scarps, when built "en décharge," is sometimes paid over with mineral tar, to add to the dryness of the casemate.

Asphalte, when prepared, is a very dense substance. With regard to the quantity used in covering a given space, and the expense thereof, the following statement, drawn up by the executive officer in Fort 1, will afford the required data:—

Total service of redoubt, 6227.

CONSUMPTION OF MATERIAL.

| | |
|---|---|
| Asphalte . . . . . . . . . . | 30,800 lbs. |
| Mineral Tar . . . . . . . . | 750 ,, |
| Coke . . . . . . . . . . . | 3,350 ,, |

ESTIMATE.

| | Th. | sg. | p. |
|---|---|---|---|
| 30,800 lbs. Asphalte, at 3 th. 10 qr. per 107 lbs. . | 959 | 15 | 1 |
| 750 lbs. Mineral Tar, at 12 th. 15 qr. per 107 lbs. | 87 | 18 | 16 |
| 3350 lbs. Coke, at 16 qr. per 100 lbs. . . . | 17 | 26 | 0 |
| Labour in laying on, preparing, &c. . . | 97 | 0 | 0 |
| Transport, Tools, &c. . . . . . | 19 | 0 | 0 |
| Total . Thalers | 1180 | 29 | 7 |

The expense per square foot is, therefore, about five silver groschen or about sixpence English currency, per square foot. It follows also, from the above data, that each square foot requires of the composition—

| | | |
|---|---|---|
| Asphalte . . . . | $4\frac{23}{24}$ | about 5 lbs. to the square foot. |
| Mineral Tar . . . | $\frac{3}{24}$ | |

Mineral tar is also used in the joints of the stonework of the cordons, and other cornices. It is likewise used for pavements. About one-third gravel is in the latter case thrown into the asphalte when boiling.

In Caponniere (prin.), in Fort No. 5, the casemates are covered with a sort of beton, composed of one and a half measure Trass, one and a half unslaked lime, five of screened gravel (the pebbles about the size of a pigeon's egg), and sufficient water to mix them. It is laid on the surface four inches thick. It is brought to a general surface by a straight edge, and when the mass begins to heat from the slaking of the lime, it is beaten by the hand with small wooden and flat hammers till it is quite cool; subsequently it will receive two coats of asphalte. It seems advisable, after such a mass of concrete has been laid on a building and allowed to dry, to give it a good thick coat of whitewash.

As regards the applicability of asphalte as a covering for casemates, its use has not hitherto been sufficiently extended to enable a decided opinion to be given either as to its durability or its capability of keeping out wet. It was used in the engineer works in Köln in 1840, and those buildings which were at that time asphalted remain dry,

The redoubt in the Weissen Auen Lage, in Mayence, is entirely covered with a timber roof, slated. Several other redoubts are also there similarly protected. This is undoubtedly the most effectual way of guarding against the effects of weather. The expense, however, in the first instance, after my views, would exceed greatly that of asphalte, while a constant outlay would be required to maintain it.

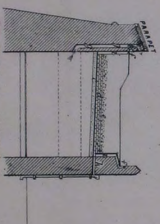
# PLYMOUTH CITADEL.

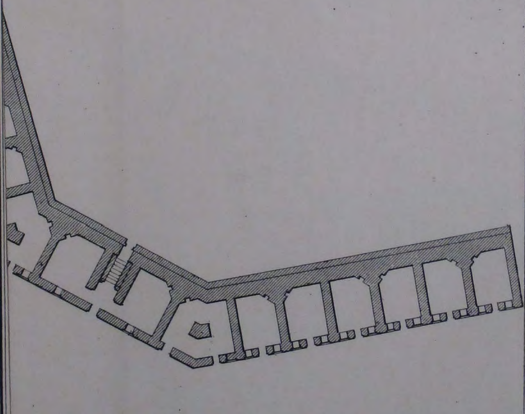
*Plans, Sections and Elevation shewing the manner in which the Casemates were rendered dry by the application of Claridges Syssel Asphalte as approved by the Boards Order Dated 25th May 1846 $\frac{E}{746}$.*

## REFERENCES.

aaaaa... *Rubble Masonry built in Mortar.*
bbbbb... *Concrete 6 in. thick, floated to receive Asphalte.*
ccccc... *Syssel Asphalte ⅝ in. thick laid in two Coats broken jointed.*
ddddd... *Brick Drains to lead the Water that may soak through to the Water Trunks.*
eeeee... *Rubble Stones laid in dry over the drains covered with Shingle.*
fffff... *Asphalted Brickwork in groove in Parapet 6 in. above Banquette.*
ggggg... *Ventilating Flues cut in Masonry of Parapet.*
hhhhh... *Asphalte on Superior Slope of Parapet secured to Brickwork laid on flat in Asphalte, covered on face and gritted on out and inside edges.*
......i i... *Asphalted Brickwork covered on face and bedded and jointed in Asphalte.*
.......k... *Cast Iron Gutters coated inside with Asphalte.*

SECTION ON LINE C.D.
SHEWING THE DRAINS

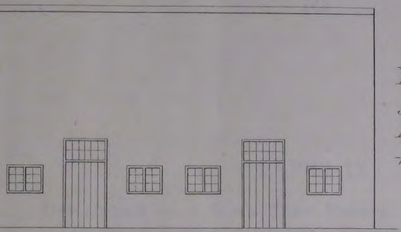


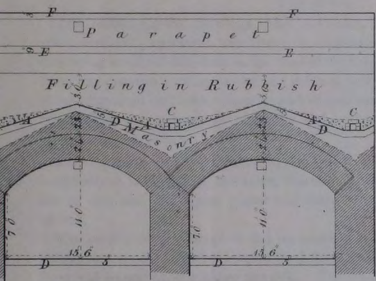
Standidge & Co. Litho Old Jewry

# PLYMOUTH CITADEL.

*Sketch shewing the covering of Seyssel Asphalte over the Casemates. and Asphalted Brickwork.*



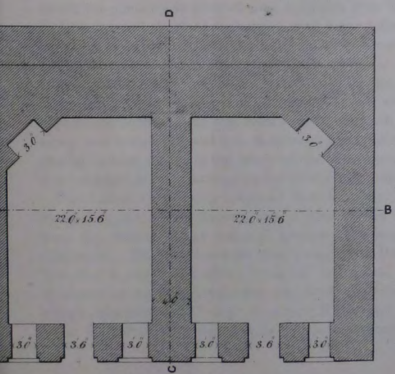
FRONT ELEVATION.



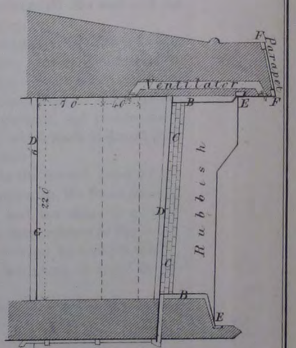

SECTION ON LINE AB.

### REFERENCE.

A. Blue Asphalte over Arches laid 5/8 in thick.
B. Asphalted Brickwork.
C. Brick Drain.
D. Concrete 5 in thick.
E. Asphalted Brickwork in Grooves Gritted on face.
F. Asphalte on Parapet 5/8 in thick, finished with Brick on Flat, Asphalted on Out and Inside edges.
G. Alphalte Floor 3/4 in thick.




GROUND PLAN.




SECTION ON LINE CD.

SCALE OF FEET.


Standidge & Co. Litho London.

# PAPER IX.

## Description of a Sixty Tons Hopper Barge, used at the Harbour Works, Alderney. From Drawings, &c., by James May, Esq., C.E., Harbour Works, Alderney. Communicated by Captain Hassard, Royal Engineers.

### The Hull.

The accompanying drawings (plan, elevation, longitudinal section, and two cross sections), represent the Barge as originally constructed for the purpose of conveying small rubble-stone to the base of the breakwater. The stone was brought from the quarries in waggons by the railway, and tipped into the Hopper from a shoot supported on timber framing, and thence conveyed to the breakwater by the Steam Tug, and emptied through the Hopper by the two trap-doors and gearing shewn in the drawing.

The Barge is built of Dantzic fir timber, with the exception of the keel, the longitudinal floor pieces, the stern, the stern posts, and the Hopper doors, which are of elm, and the apron pieces and knees of the stem, stern posts, which are of oak.

The bottom of the Barge is flat on account of grounding each tide; there are, in addition to the keel, five longitudinal floor pieces of the same scantling, running from end to end except under the well. The planking and deck is 3 inches thick, and the planking round the well 4 inches thick, caulked watertight.

To prevent the Hopper from being destroyed by the stone descending from the shoot, the planking is covered with malleable iron bars 4 inches thick by $\frac{3}{4}$ inch, laid on flat, and about $1\frac{1}{2}$ inch apart, care being taken to avoid the seams of the planking, so as to give access for caulking when necessary.

The *trap doors* are worked by a single purchase double crab, with a barrel, wheel pinion, and $\frac{3}{4}$ inch chain for each door; the two pinions constructed to throw out of gear by means of two clutch levers, which move the two pinions in opposite directions along the centre shaft, and each chain from its barrel passes along two horizontal cast-iron sheaves placed on the gunwale, and thence over a similar vertical sheave in the centre of the cross-beam, which leads it direct, with two branches, to the shackles on the sides of the trap-door.

The loaded Barge being conveyed from the shoot to the desired point by the Steam Tug, the crab is thrown out of gear by the bargemen, the doors descend from the weight of the material bearing on them, and the stone is at once discharged. The trap-doors are then heaved up as the Barge returns to the shoot. The crab is also fitted with a break for each barrel, worked by a single handle, by means of which a breaksman can hold on, with sixty tons of stone in the Hopper, the machinery being out of gear, if required.

For the purpose of warping to and from the moorings, the Barge is provided with a winch on the after-deck with a barrel of elm worked by single purchase gear. The stern-post is fitted with a rudder. With three Barges of this description, and the Steam Tug, as much as two thousand tons of stone have been deposited in one day, at an average distance of three hundred yards from the shoot.

THE DIMENSIONS OF THE BARGE, AS UNDER:—

| | Ft. | In. |
|---|---|---|
| Length of keel | 49 | 2 |
| Length over all | 53 | 0 |
| Width of beam | 18 | 8 |
| Width below | 14 | 8 |
| Extreme height from keel to deck, fore and aft | 7 | 3 |
| Ditto, in centre | 6 | 6 |
| Sheer | 0 | 9 |
| Length of well at top | 21 | 0 |
| Ditto, at bottom | 10 | 0 |
| Width of well at top | 16 | 4 |
| Ditto at bottom | 6 | 0 |

Keel and floor pieces, 9″ × 6″
Kelson . . 12″ × 12″
Timbers . . 9″ × 8″
Planking 3 in. thick, 4 in. round the well, deck 3 in. thick.
Stem and sternpost, 10″ × 9″
Doors two thicknesses of 3″ elm planking.
Draft (light) 3 feet.
Ditto loaded with 60 tons, 5 ft. 6 in.
Fastening all of iron.

| | |
|---|---|
| Pitch of spur wheel and pinion of winch | 12″ |
| Ditto of double crab for working hopper | $1\frac{3}{8}$″ |
| Ditto of single motion for large stone crab | $1\frac{3}{8}$″ |
| Ditto of double motion for ditto | $1\frac{1}{2}$″ |
| Ditto travelling gear of large stone crab | $1\frac{3}{8}$″ |

LARGE STONE APPARATUS.

In the course of last season (1850) it became necessary to remove large pieces of rubble-stone, averaging each from four to eight tons in weight, from the accumulated beach inside the breakwater, and place them in front of the foundations of the sea and harbour walls, for which purpose the apparatus distinguished in the elevation and section, and supported by frame-work above the general level of the deck of the barge, was erected.

The framing consists of six uprights of Memel timber 12″ square, secured to the deck beams by cast-iron knees, and supporting two longitudinal timbers of same scantling, 50 feet in length and 6 feet apart, projecting 7 feet clear of the stern. The longitudinal pieces are secured to the uprights by wrought-iron straps bolted through. The top of the longitudinal timbers is elevated 7 ft. 3 in. above the deck in the middle of the barge, and each timber carries a line of flat-bottomed rail spiked to the beam and turned up at the ends, as shown in the drawings. The centre openings over the well and the ends projecting beyond the stem, are further supported by the diagonal pieces 8″ × 8″, and the extreme ends of the roadway beams are tied together by two cross pieces 12″ square.

Each roadway beam carries for its whole length a footway, 30 inches wide, of 2½ inch planking, resting on three cast-iron brackets bolted to the uprights.

Near the fore end of the staging a cast-iron friction roller is placed, 6 inches diameter, resting on plumber blocks bolted to the under side of the roadway beam.

Along the line of rails on the top of the beam, a double purchase travelling crab traverses, which is shown in the elevation in two positions, marked E and F.

The process of conveying large stones from the beach to the base of the Breakwater, is as follows:—

The empty Barge being moved stern on to the beach, a sling chain is passed round the stone, which is hooked to the ¾-inch chain from the crab in the position F, and to prevent the chafing of the timber in cases when the stone may happen to be at some distance from the vessel, the chain passes under the friction-roller. The crab thus brings the stone under the bows of the barge, and thence by traversing the line of rails places it in the Hopper; when the barge is loaded it is moored to the staging at the face of the wall. The hook at the end of the crab chain is then passed round the stone in the Hopper, and hooked into a spring-hook suspended from a shackle on the bight of the chain. The stone being thus hoisted from the Hopper is again taken by the crab into the position shown in the elevation, and dropped over the bows by unhooking the spring-hook with a small rope attached to it, by a bargeman on the deck.

The crab, E, with the chain passing under a cast-iron sheave on the deck, and over a similar sheave at the fore end of the staging, represents the position proposed for lifting blocks of fourteen to sixteen tons.

The object being to remove the stones without bringing them into the Hopper. In this case six or eight tons of ballast are necessary in the afterhold to trim the Barge. A manrope runs round the side of the Barge, passing through ten iron staunchions placed to ship and unship, in sockets on the gunwales.

The cost of a new Barge of this description, fitted with staging for large stones, hawser, anchors, chains, crabs, and machinery, complete, would be about 600*l.*

All the barges used at the Alderney Works are built of timber; but from experience of the wear and tear by frequent grounding, loading from the shoot, &c., it is thought that Barges built of strong boiler-plate, with angle iron ribs, knees, &c., commonly used in iron ship-building, would be preferable.

F. C. HASSARD,
Capt. Royal Engineers.

*Sep.* 29, 1852.

# PAPER X.

## Observations on Groins, during Five Years at Eastbourne on the Sussex Coast, and five Years at Hythe in Kent. By Lieut.-Col. Gordon, Royal Engineers.

1st. I am of opinion that a Groin ought not to be constructed perpendicular to, or in immediate contact with, the work which it is intended to protect from the violence of the winds and waves; or if its object be the accumulation of sand and shingle at its base.

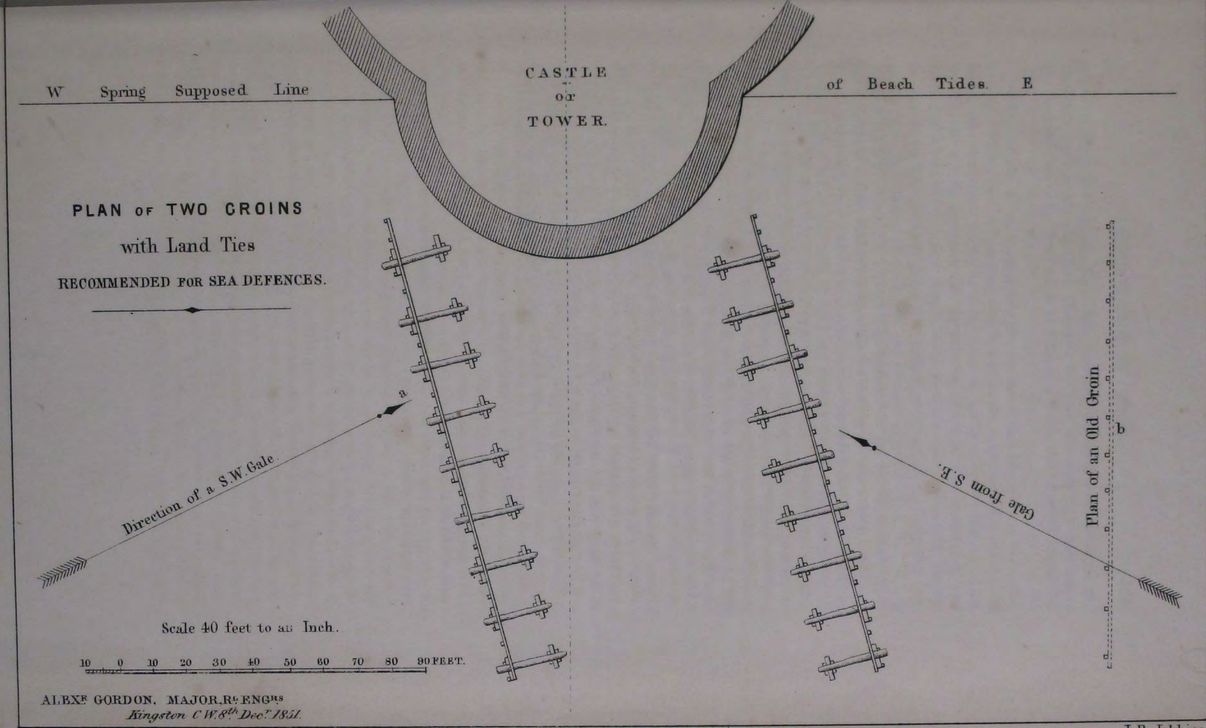
2ndly. In all cases two groins at least are required for the defence of one work, and their positions will be on either side of and at such a distance from it, as observation and local experience may suggest.

3rdly. The groins should not be placed perpendicular (vide *b*) to the usual flowing of the tides in fine weather; but they ought to be *en echelon* to the periodical high seas and winds, which threaten the destruction of the work: that is to say, the sea should strike upon, and wash over, a groin in an oblique direction, having the obtuse angle formed by the groin and the wave on the land side (vide angle *a*), so that the sea on its recession will leave the ejected sand and shingle on the opposite side of the groin, which in time will accumulate at the foundation of the work by means of the land-ties, and these form the steps suggested at page 61, First Volume of "Corps Papers."

4thly. All groins should have land-ties of rough round timber, similar to those at the Circular Redoubt at Eastbourne, Sussex, and at Sandgate Castle, Kent; the heads, or larger ends of the ties, will be best placed projecting through the groin towards the advancing combined effort of the high winds and seas. The tails of the ties will, therefore, be on the opposite side; and as the sand and shingle collect over these ties, the weight of which will tend to strengthen and consolidate the whole of the groin.

5thly. The end of the groin towards the land ought to be about the height of the beach, formed by the spring tides; and the edge of its upper planking may be directed on, and graduated to, a point at low water mark, at spring or neap tides. The length of groins, and their intermediate distances, are points which I must leave to the experience and judgment of those who may be engaged in groining operations, because there are many reasons which preclude the possibility of giving fixed or arbitrary data thereon.

6thly. A groin constructed of hard wood costs about one pound sterling per running foot; but there is another description of groin, designated "Wicker-work, which I constructed for the defences of the Martello Towers, &c., in Sussex (under the command of Sir John Burgoyne, Com. R. E.), composed of posts, fascines, poles, and wicker-work, which completely answered the purpose for which it was intended. The expense of this description of groin cost about eight


PLAN OF TWO GROINS
with Land Ties
RECOMMENDED FOR SEA DEFENCES.
W Spring Supposed Line
CASTLE
or
TOWER.
of Beach Tides. E
a
Direction of a S.W. Gale.
Gale from S.E.
b
Plan of an Old Groin
Scale 40 feet to an Inch.
10 0 10 20 30 40 50 60 70 80 90 FEET.
ALEXR. GORDON, MAJOR, Rl. ENGRS.
Kingston C.W. 8th Decr. 1851.

J.R. Jobbins

or ten shillings per running foot; this, however, was in a locality where the materials were pretty abundant, therefore the cost will vary in proportion as the materials are to be found on, or at a distance from, the intended site of the work.

Finally, to me, it has been clearly demonstrated that if a groin of the latter description answered the purpose equally well as the more expensive one of hard wood, that the former might, in many cases, be safely adopted; because a hard wood groin having answered the purpose for which it was constructed, and becoming buried in sand and shingle, which cost the Government 300*l*., is only as efficient as a wicker-work groin in a similar position, the cost of which was about 120*l*. A wicker-work groin has one evident advantage over that of one constructed of wood, viz., its almost non-resistance to the sea, as the water flows through its countless interstices, but the wooden groin has only the joints or openings between its planks for the water to pass through: and hence it will be apparent, that the united force of wind and wave on a wooden groin is one of the great causes of its destruction; and another great cause is, that of the recession of the tide taking the line of the groin, on both sides, by which it becomes undermined and rooted up.—Vide Note by Editors, at page 61, First Volume of "Corps Papers." "If the shingle be watched, it will be seen to move obliquely upwards under the action of the impelling wave, and then, as the wave recedes, to roll almost perpendicularly to the line of beach downwards; and it therefore follows that the tide would roll down both sides of an ill-placed groin, such as at *b*, which is perpendicular to the beach, and without land-ties."

Need I add, that a slight and flimsy substance has often been the cause of parrying the deadly effects of a bullet; and it is also well known that a pebble or stone has directed shot and shell from their original objects: hence the same reasoning holds good as regards the efforts of the high sea and wind, where defensive obstacles are judiciously placed in their way. These remarks I beg to submit with much diffidence, and I trust they will be accepted at their value; that is, the result of ten years' practice and experience of

Your obedient humble servant,

ALEX. GORDON,

Lieut.-Col. Royal Engineers.

Kingston, C. W., 8th Dec. 1851.

To the Editors of the "Corps Papers," Woolwich.

# PAPER XI.

## Revetments or Retaining Walls. By Lieut.-General Sir John Burgoyne, Inspector General of Fortifications.

Revetment is a term used in Fortification, and usually comprehends other requisites besides that of merely sustaining the bank of earth: the following memoranda have only reference to the latter quality, and therefore the subject is to be considered as of *retaining walls.*

Elaborate treatises, founded on abstruse mathematical reasoning, have been published on the pressure of earth, and the proportions to be given to retaining walls under different circumstances; they are proper elementary studies for every engineer, and may be consulted in framing projects for very great works; but a few simple rules, easily retained in a note-book, or even in the memory, will be very useful for ordinary practice and observation: of this kind are the data given by General Fanshawe, in the First Number of the "Corps Papers," namely, for a medium thickness of a retaining wall, of brick, to multiply the height by ·25 where there is a batter of one-sixth, and by ·31944 (say ·32) when the wall is vertical in its exterior face and countersloping within; or, what might be more easily remembered, take one-fourth of the height for the mean thickness of wall with the batter, and one-third very nearly for the vertical; always assuming the backing of earth to be of the same height as the wall, and no more.

This calculation is full and secure, provided the foundation, the material, and workmanship be good; but it is worthy of consideration, whether such rules are to be adhered to rigidly in all cases, or whether under a variety of circumstances and arrangements, the proportions might not be reduced without risk.

Very precise data from *facts* are much wanted; records of failures with minute particulars would be most interesting, but are not to be obtained; experiments have rarely been made,* except on small models, which latter are anything but satisfactory; these models are made of one rigid substance (wood), cut into the shape of the entire wall, and being loaded at the back with sand, bullets, or small shot, are proved as to the relative weight or force required to turn them bodily over on a pivot at their toe. Many useful analogies may be drawn from such trials, but as the action on a wall loaded with earth is very different, they might in some cases mislead, and cannot be considered in any as quite conclusive.

Under this impression, when Chairman of the Board of Public Works in Ireland, I took a favourable opportunity that presented itself at Kingstown, of entering upon a series of experiments on actual walls, which, unfortunately, circumstances did not admit of being continued to the extent contemplated; the first made however are interesting, as far as they go, and are exhibited in the Plate which accompanies this paper. Four walls were constructed of equal length, height, and mass, but of different figures, and then loaded at the back with

* A few were made by Lieut. Hope, Royal Engineers, at Chatham, under the orders of Colonel Sir Frederic Smith, reported in vol. vii. Professional Papers, and are interesting.

earth, as nearly as could be under the same circumstances; a medium thickness of one-sixth of the height was taken as a minimum, that would afford a chance of observing the relative order and manner in which each would successively give way, without contemplating that any would entirely resist, as it proved that one (the leaning parallel figure) did.

The intention was to have made further trials on those which had failed, by increasing their solidity in an uniform degree, when probably, at one-fifth mean thickness, the wall (of that peculiar description and weight of stone) with a batter would have been found to have sufficient stability, and in succession that with a counterslope would have shown its advantages over the parallel vertical wall.

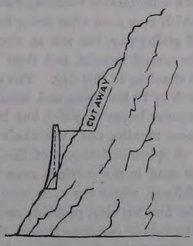
It was also in contemplation to try the effect of applying counterforts, as part of the mass of masonry.

It may be observed, that as to the positive power of resistance, these experiments may be considered as having been somewhat trying. They were made in winter, the soil wet, and the weather unfavourable; the filling was of earth, thrown in loose and without any precaution of ramming or otherwise; the walling without mortar, and each portion of 20 feet in length, not connected or tied in at the ends to any other support; the only favourable circumstance was, being based on a thoroughly unyielding foundation—rock.

There are differences of opinion relative to the advantages of applying part of the masonry in the form of internal buttresses or counterforts, even as regards the stability of the wall; that is, independent of the military consideration of the resistance it may afford against being breached. The first matter for experiment and decision, however, is the best form of cross section for the facing of the wall. as that will not be affected by the question of the counterforts.

There are two points worthy of notice regarding the counterfort principle, that are not taken into consideration in mathematical reasoning, or in the trials with wood models; one is, the additional cost of the workmanship by the increase of surface lines to be worked to,—and the other, the tendency of the pressure to tear the facing from the counterforts; which, where the wall gives way, it always does more or less, showing a weakness in that point not exhibited in the models, which, on the contrary, produce an increase of power in that part, by the lengthened leverage of overhanging weight opposing the effort to overturn it.

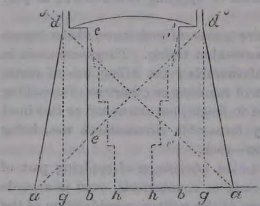
Independent of the reasoning on the abstract relative advantages of particular forms and dimensions for the section of a retaining wall, there may be peculiar circumstances of locality or nature of the work, that may lead to a deviation from any uniform rule; of which the following are examples:—




1. In Sir Henry Parnell's "Treatise on Roads," containing many valuable details of that magnificent work, the great Holyhead road, will be found a section descriptive of the mode in which it was carried along the side of a precipitous rocky mountain; in which it will be seen how a good rule for ordinary circumstances may be carried too far in special cases. Telford considered a curved batter and of certain dimensions a good form for a retaining wall, and this seems to have been followed here without reference to circumstances, for there can be no doubt but that a vertical wall, as

shown by the dotted line, would much sooner find its base, and with far less work and material, would have been quite as efficient; and very great strength of wall was the less necessary, as the filling must have been, not of earth, but of the pieces of excavated rock, giving no elastic pressure, but merely dead weight, and even that capable of being very much relieved by a little pains given to packing them.

2. In another case, a road in Ireland was to be carried across a ravine, by a high embankment with retaining walls; the road was required to be 21 feet wide between the fences, and 30 feet above the bottom of the valley. The retaining walls were planned on the ordinary rules, as *a, b, c, d,* in the figure, with an external batter of one-sixth; these, therefore, were calculated to resist a pressure of a filling included in the section *c, e, f, c′, e′, f′,* whereas it will be seen how much short of that bulk the real filling occupied, and which bore upon each wall; but by altering the shape, and adopting a wall vertical externally, and removing the front projection of batter to the counterslope in the interior, that is, to the lines *g, h, c, d,* it will be found that a great part of the *filling* would have been of the masonry, to a great saving of labour in filling, and of pressure on the walls; and a saving of land by the projection *g, a,* for their entire length.




3. Another cause of occasional failure in retaining walls, or of an excess of masonry to avoid it, arises from their being built almost universally under very unfavourable circumstances, that occasion a violent pressure on them of short duration; and that when they are in their weakest state: thus, these walls are usually constructed rapidly, and while green and their mortar unset, backed with earth, which for a period is gradually settling, and exerts a powerful effort on them; they consequently require to have a mass proportioned to resist these *temporary* disadvantages, whereas when the backing is well consolidated, and the wall dry, much smaller proportions would be ample. I have witnessed the case of a considerable retaining wall, of proportions somewhat less than the rules admit, which very soon after being backed with earth began to bulge, and showed signs of giving way, but was at once strongly shored up with timbers, which were left for several months, and then removed; since which the wall remained firm, and is standing to this day. The same of the two abutments of a bridge, of a single arch of 18 feet span, and immediately backed with earth; the walls in a similar manner began to yield, but being well strutted with stout timbers and plank for some months, until the whole was thoroughly settled, remained firm ever after.

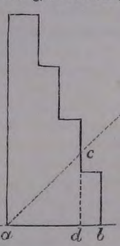
A splendid instance of this kind of remedial measure, judiciously applied, may be seen in the cuttings near the Euston Square Station of the North Western Railway, where the walls were found to be insufficient to support the pressure of the London clay, probably as trying a substance as any in the world; and those fine curved cast-iron girders that may be now observed, were fixed from wall to wall spanning the entire road. I have no doubt, however, but that even that soil, after so many years of being cut through and sustained, will, with the walls, have acquired such a consistence, as not now to require that precaution; and as it is in some degree an eyesore, in interfering with the simplicity of the work, and would appear to be superfluous, it is to be expected that some day a single girder will be removed, and others in succession, and gradually in alternate order to try the effect, and that finally the whole will disappear.

The power of resistance of the leaning parallel wall has been long known, and that form might be generally applied instead of the ordinary batter given to the external face only, but for one great inconvenience, which is, the necessity for carrying up the filling behind it, at the same rate as the wall rises, in order to support it from falling *inwards*.

The results of the single trial at Kingstown may lead to a belief that the wall, vertical in its face and countersloped in rear, affords less resistance in proportion to one with the ordinary external batter, than is commonly calculated upon; and it would be a matter of peculiar interest to have decided by thorough actual experiment; at the same time it would still be in very many cases the better form to adopt, in consequence of the serious disadvantages and evils of the external batter, particularly in brick.

The internal counterslope is usually carried up by offsets, which (the courses being horizontal) are quite as easy in building, and they give a slight increase of resistance, and perhaps might give more, if by their means the greater thickness of wall was adjusted, on experiment, to the points where the pressure is greatest rather than by the usual regular gradation.

For instance, *a*, *b*, *c*, being within the angle of repose of the filling, has scarcely any pressure upon it, and consequently only serving as the base of the wall above, no extra thickness, as shown in the figure, need be given to it; but the line being brought down from the next offset above (as to *d*), the portion *d*, *b*, might be suppressed, and given to increase the strength of the wall above.



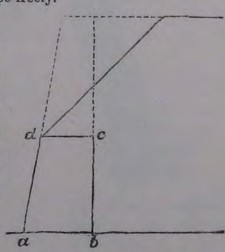

It may not be superfluous to add a reminder on two or three well-known circumstances, that never must be lost sight of in the construction of retaining walls:—

1. The absolute necessity of securing a thoroughly good foundation, as any yielding at the base will peculiarly influence the stability of such walls.

2. To provide weep holes through the wall, to allow the water, as it drains from the filling, to escape freely.

3. To allow in the calculations for the strength of wall, for the nature of the material employed, its specific gravity, &c.

4. To avoid (what is the cause of many failures) the not proportioning the retaining wall to the height of the earth which it has to support, instead of merely to that of the wall; thus *a*, *b*, *c*, *d*, being the lower portion of a wall calculated to the full height of the embankment, will be the section required to support the foot of it.




Escarps in fortifications are frequently given a form and strength exceeding the dimensions required of them, as retaining walls only, and at considerable more

expense, in order to obtain a prolonged resistance from the effect of an enemy's breaching batteries; but this precaution may be carried too far; if applied generally to the whole contour of the place, it will add very importantly to one of the most costly items of expense, and will be superfluous on every part but those that present the greatest facilities of approach to a besieger.

In general it will be more advantageous to adapt the escarps to a system of masonry, that will in the most economical manner retain the mass of earth behind them, reserving the extra means for adding to the difficulties of being breached—for any part that may be peculiarly liable to be attacked, and making that as strong as possible by arches carried through to the external face, in the manner designated by the French engineers as *en décharge.* On many occasions, this valuable accessory for defence may be obtained without extra expense, by making these arches part of the necessary bomb-proof cover for the accommodation and use of the garrison.

Whatever reasonings may be held out for reducing the dimensions of retaining walls, that are not confirmed by actual experience or trial, must be received with caution.

The old rule of making everything stronger than strong enough, must be particularly attended to by our military engineers; at the same time let us anxiously look out for every possible improvement, that will tend to stability in the first instance and to economy in the second.

J. F. B.

## REFERENCE TO PLANS AND SECTIONS OF REVETMENT WALLS.

The masonry of the leaning wall, section A, and the earth falling at the rear, commenced 20th of October, 1834, and proceeded, *pari passu*, until the wall was carried to its full height. At this date (31st of December) the wall remains unaffected by the lateral pressure of the earth filling, although kept to its full height, from time to time as subsidence occurred.

The masonry of the sloping wall, section B, commenced on the 20th October, 1834, and was carried to its full height on the 27th of the following November. The earth filling in the rear was begun on the 20th of November, and completed on the 6th of December. The deficiencies from subsidence, in the filling, were made good from time to time, as in the preceding case. Since the completion of this section the slope in front is diminished 2½ inches, and there are some slight fissures in the face of the wall indicative of instability.

The masonry of the counter sloping wall, section C, was commenced and completed concurrently with section B. The earth filling in the rere was commenced on the 20th of November, and on the 6th of December, when the filling attained the height of 17 feet, the wall was overturned. The overseer reports—" at one o'clock, P.M., the counter-sloping wall fell, the filling 17 feet high behind the wall; it overhung 10 inches, was greatly convex on the face, and rending in every direction; it overhung five inches in the first 5 feet of its height. In falling it burst out at about 5 feet 6 inches from its base, and two-thirds of the wall from the top, downwards for its full length, kept in an upright position, until it reached and was crushed on the ground." See diagram C, fig. 2.

The masonry of the rectangular wall, section D, was built at the time sections B and C were erected. The earth filling in the rear was commenced on the 20th of November, and on the 6th of December, when it attained the height of 17 feet, this wall was also overturned. The overseer reports—" at four o'olock, P.M., the rectangular wall fell, the filling 17 feet high behind the wall; it overhung 1 foot 6 inches, convexity on the face more than 4 inches; it fell like a board, having increased in the overhanging from 1 foot to 1 foot 6 inches, from half-past three till four o'clock, when it fell." See Diagram D, fig. 3.

The several walls were founded on solid rock.

---

### A TABLE

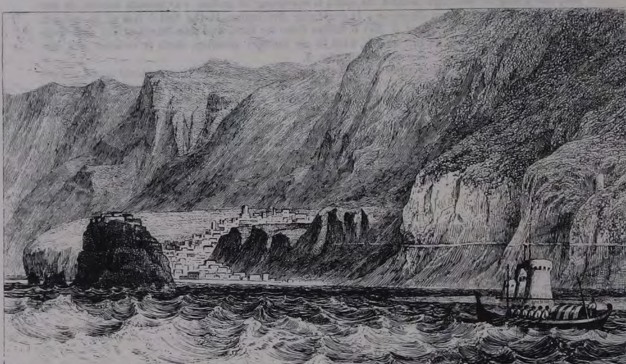
### SHOWING THE HEIGHT TO WHICH THE CLAY-FILLING WAS CARRIED EACH DAY DURING THE PROGRESS OF THE WORK.

### ALSO A DIARY OF THE WEATHER.

| Dates. | A | | B | | C | | D | | State of the weather. |
|---|---|---|---|---|---|---|---|---|---|
| 1834. | Morning. | Afternoon. | Morning. | Afternoon. | Morning. | Afternoon. | Morning. | Afternoon. | |
| Commenced 20th Oct. | F. In. | F. In. | F. In. | F. In. | F. In. | F. In. | F. In. | F. In. | |
| November 7 .. | .. | 5 0 | .. | .. | .. | .. | .. | .. | Dry. |
| " 8 .. | .. | 7 0 | .. | .. | .. | .. | .. | .. | |
| " 19 .. | .. | 11 0 | .. | .. | .. | .. | .. | .. | Rain. |
| " 20 .. | .. | 14 0 | .. | .. | .. | .. | .. | .. | |
| " 26 .. | .. | .. | 2 6 | 2 10 | 4 0 | 6 4 | 4 0 | 5 6 | Dry. |
| " 27 .. | .. | .. | 3 0 | 4 9 | 7 0 | 7 6 | 6 0 | 7 0 | |
| " 28 .. | .. | .. | 6 0 | 8 0 | 7 9 | 8 0 | 7 0 | 8 4 | |
| " 29 .. | .. | .. | 8 0 | 11 0 | 8 0 | 9 9 | 8 4 | 8 4 | |
| " 30 .. | .. | .. | 10 8 | .. | 9 6 | .. | 8 8 | .. | |
| December 1 .. | .. | .. | 10 8 | 11 6 | 9 8 | 10 2 | 8 8 | 9 9 | Much rain during night. |
| " 2 .. | .. | 20 0 | 11 9 | 12 0 | 10 4 | 11 4 | 10 2 | 10 6 | Rain during night. |
| " 3 .. | .. | .. | 12 0 | 13 0 | 11 4 | 11 0 | 10 6 | 13 0 | Dry. |
| " 4 .. | .. | .. | 12 9 | 12 6 | 11 0 | 13 8 | 12 6 | 13 8 | |
| " 5 .. | .. | .. | 12 6 | 13 6 | 13 3 | 14 4 | 14 8 | 15 4 | |
| " 6 .. | .. | .. | 15 6 | 20 0 | 15 3 | 17 0 | 15 3 | 17 0 | |
| " 7 .. | 20 0 | .. | 20 0 | .. | Fallen. | | Fallen. | | Much rain during night. |

# PAPER XII.

Some Account of the Field Works thrown up for the Defence of Sicily in 1810, with a Plan by Major-General Lewis, Royal Engineers. With a plan illustrating the works.



T Bridges

THE CASTLE OF SCYLLA FROM THE FARO

J R Jobbins 3 Warwick C.t

## Preliminary Remarks.

Many circumstances rendered the possession of Sicily apparently an easy task to the French army, in Naples, at the commencement of the year 1810. The conquest of the kingdom of Naples was complete, the island of Capri taken, dislike of the Sicilian Court to the English open if not avowed, and the retreat of the Anglo-Portuguese forces in the Peninsula, probably induced the Emperor to sanction Murat's making the attempt on Sicily.

Accordingly that distinguished general commenced preparations early in the spring of 1810, strengthened his force in Lower Calabria, and he collected a large fleet of boats in the Bay of Naples. When he, Murat, had completed his arrangements, the flotilla, many of them armed as gun-boats, moved southwards in squadrons, keeping in shore as much as possible, protected by moveable columns of troops. The lighter or transport boats, if pursued, were drawn up on the beach in the bight of the several bays in the Neapolitan coast, flanked by the armed part of the flotilla and the field artillery of the moveable columns; and by these precautions from day to day, six hundred vessels were brought down with very little loss to the coast opposite Sicily, and there planted until a suitable opportunity arrived for the attack. And this was effected without a single harbour or shelter of any kind between Scylla and the Mole of Naples.

Colonel Sir Alexander Bryce, who commanded the engineers of the Anglo-Sicilian army, in his official reports, dated Messina, July, 1810, describes these operations as follows: "I snatch a moment from professional duties, which have been very severe, to say that King Murat is now endeavouring to put in execution his long-threatened invasion of Sicily.

"He is encamped between the Point of Pizzo and Scylla, where the straits are only two miles wide, with a force, as nearly as we can learn, of about 25,000 men. His naval means are, I believe, about eighty heavy gun-boats, as many lighter armed boats, four galleys, and about 450 transport boats for troops.

"We now have about 120 armed boats of various descriptions; two ships of the line and two frigates are moored in convenient situations for protecting the beach, whilst the Admiral, with two others, is cruising outside the Faro.

"All our troops are collected here, excepting the garrisons of *Augusta, Syracuse, Melazzo*, and *Trapani*. The whole coast on each side of Messina has been furnished with sea batteries, on traversing platforms—emplacement for field artillery and troops. And an important point, the extremity of the great ridge of mountains, which terminate near the Faro, and the key of the whole of the narrow part of the straits, has been strongly entrenched with field works, with a redoubt on the top, which in a short time will, I trust, be capable of sustaining a short siege, should we be forced to leave it, for two or three days, to its own resources, whilst we are concentrating our means for a general attack, before he can establish himself firmly at the Faro.

"Roads of communication have been formed in all directions, and an entrenched camp for covering Messina marked and forming.

"I think I may now venture to say that we are, *as far as Murat's force is concerned*, in a very good state of defence, and I assure you the fatigues and exertions of the corps here have not been small, weakened as we are by the necessary detachments."

The annexed plan to this subject will explain the relative position of both armies, with a description of the fortifications constructed for the defence of the coasts. The success of the enemy in bringing so large a flotilla opposite Sicily was not continuous, for the reinforcements brought down were attacked by our cruisers. And Sir Alexander Bryce in another report, dated the 22nd August, 1810, remarks, "that our ships of war had destroyed one part of a convoy with reinforcements, and captured the whole of another with artillery and provisions." The success of the early squadrons of boats arose principally by surprise, our cruisers not having information of their departure from Naples, in the first instance, and having been blown off probably by adverse winds for a few days.

Nevertheless in another report, dated Messina, October 24th, 1810, Sir Alexander Bryce informs the Inspector General of Fortifications that King Murat had retreated to Naples. He observes, "You probably know ere this, that we are no longer threatened with an immediate attack by Murat, who has broken up his encampment opposite us, and sent his troops into winter quarters. His flotilla has returned to Naples without having been much harassed by our ships on its voyage, and our troops are enjoying a little rest after their long continued labour and watchings. I must, however, except myself and officers, who are still busily engaged in rendering more permanent our field defences, and taking advantage of the time to construct several additional works for the better defence of the straits, which I trust will be finished before it is probable that Murat should return in the spring. He has left his depots of heavy artillery and stores at Scylla, and those of a lighter nature in the Bay of St. Euphemia, which circumstance, coupled with the ease with which he has sent and withdrawn his armament, would seem to indicate a repetition of his attempt. I however believe that he has found the expenses very great and burdensome on his dominions. It is, therefore, not improbable he may be prevented by a want of the necessary funds from returning soon. Indeed it is difficult to assign any other reason for his having withdrawn the other day, as the winter would, in my opinion have been rather more favourable to his chances of passing the straits, whilst our fatigues in guarding against it during the long and dark nights of winter would have been greatly increased.

"Altogether we have had a very novel and curious kind of campaign, not without considerable instruction, and as the result has been satisfactory and honourable to the army, I cannot regret having had some share in it. I have every reason to be satisfied with the zeal and intelligence of the officers under my orders, and as Sir John Stuart has on all occasions admitted me to his full confidence, and expressed much satisfaction with the various and extensive operations of the corps, I have no doubt he will take the opportunity of his public despatch to manifest his sentiments."

In perusing the narrative of events in Sicily during the summer of 1810, the unsuccessful descent on the coast a few miles south of Messina has been omitted to be described for the sake of perspicuity. But it should have been stated that in September the attempt was partially made with the Neapolitan troops and repulsed. This was, in fact, meant as a diversion in favour of the real attack as proposed by Murat, which did not take place; for it appeared by information obtained about that time that General Grenier, in immediate command of the French or auxiliary troops of the Neapolitan army, objected to their embarking upon so rash an attempt; he having in his possession a veto, giving him the power from the Emperor, of refusing to employ the French troops in the event of his seeing it proper to make use of that power.

In this case it would have been the height of imprudence to have attempted a landing between Messina and the Faro, and probably have caused the destruction of the naval and military forces employed, and perhaps the loss of the kingdom of Naples. In an intermediate report, however, from Sir Alexander Bryce, dated Messina, 22nd September, 1810, he thus describes the debarkation of the Neapolitan army on the shores of Sicily:

"Conceiving that a good delineation of the military works, and the positions of the armies in this neighbourhood would be interesting, I have had one prepared. And a reference to Zanoni's chart of the Straits of Messina will supply that portion of the coast to the southwards which our scale would not admit of including.

"Our force here consists of about 13,000 troops of every description,* that of

* This does not include Sicilian, as the whole Sicilian army was concentrated at Palermo, for the protection of the court and that city, 150 miles west of Messina.—G. G. L.

the enemy from 23,000 to 25,000. But there is strong grounds for believing that a French corps of 10,000 has arrived at Rome on its way to Calabria.

"On the morning of the 18th, after three months' preparation, Murat made his first attempt at landing about eight miles to the southward, where our numerical force did not allow of our having more than a few videttes on the beach, and a small corps of light infantry on the rising ground over it. But the straits here being about eight miles broad, the brigs of war, appointed to cruise off Reggio, were supposed to afford an adequate degree of protection. The enemy however seized with much decision the advantage afforded him by the effect of a gale which forced the brigs into the harbour, and before their return crossed in boats during the night, and landed at four in the morning to the number of 3000 and upwards, advancing immediately his light troops into the mountains; our 400 light infantry, however, moved beforehand in that direction, occupying the higher ground. And three battalions advancing on his flank from Contesso, he took fright and re-embarked, leaving 900 prisoners in our possession. His loss may be computed at 1100 men.*

"From what we can learn of this ill-executed plan, the enemy seems to have intended throwing a corps into the mountains in our rear as circumstances permitted, knowing probably that we could not detach a sufficient force to dislodge them without unfurnishing our own defensive line, and leaving it exposed to his more direct front attack. He also probably reckoned on the assistance of the natives: but in this he has been disappointed, as the lower classes uniformly assembled with such arms as they had, and either joined our troops or by themselves defended the passes into the mountains.

"Indeed this good disposition of the inhabitants so unequivocally evinced on this occasion, seems to me the only consolatory circumstance in the affair, for as the enemy has been able not only to throw a force on shore but to re-embark and escape with the whole of his boats during a September night, we must naturally contemplate with much anxiety the greater facility with which he will be enabled to concoct such an operation in the long nights of the approaching winter. And should he be able to place a corps of 5000 men in the mountains sufficiently strong to overawe the Sicilians and procure provisions, our situation here would be very embarrassing."†

## The Works for the Defence of the Coast of Sicily between Messina and the Faro.

It will be seen by the plan that the shore open to invasion was about twenty miles, extending from the Faro Point southward beyond Messina, that portion being within the distance by which boats could cross the straits in sufficiently short time to escape our cruisers. For the coast itself is open to a debarkation thirty miles south of Messina, but this involved a long sea voyage for open boats unprotected; therefore little fear was entertained of an attack, beyond the twenty miles explained above, the passage here being only from two to eight miles wide. The means of attack were open boats, supported by armed vessels of a similar description, the former being able to carry upon an average fifty men.

* Aided by the armed peasantry of the mountains, who turned out with great alacrity and spirit, acted with our troops, and assisted and guided them over the rugged paths, and thus enabled them to intercept the enemy.—G. G. L.

† It should be observed, that there were hopes on the part of Murat that the French fleet in Toulon would co-operate in the attack of Sicily.—G. G. L.

The troops of the hostile force in Lower Calabria, opposite Messina, were encamped or hutted, principally upon a promontory between Rezzio and Scylla, the transport boats hauled up on the open beach, and covered by mounds of shingle thrown up in front to secure them from a cannonade, and flanked by batteries with heavy artillery, mounted on traversing platforms, and protected likewise by field artillery attached to the troops, which frequently moved down to meet our gun boats if they approached too near, and by the accuracy and celerity of their fire always drove them back with some loss. The enemy's armed boats were in the bight of the bay, under the castle of Scylla.

In this position the French Neapolitan force was frequently bombarded by Anglo-Sicilian gun-boats, supported by the ships of war, and a heavy cannonade was a constant occurrence on both sides, with very little apparent effect. And for three months Murat kept us in a state of excitement, sometimes launching his boats and embarking his men, for exercise and by way of threatening us, and his enterprising character led us to expect that his intentions some night would be carried into execution. The beautiful climate, scenery, and close approximation of the hostile forces, and every naval action in sight of both armies, rendered the time most exciting and interesting.

The artillery and engineering means of the British army were mostly supplied from Malta as regards the material, and the expenditure of powder and shot was enormous.

The artillery used on shore for the armament of the batteries were 12, 18, and 24-pr. iron, and some foreign guns of 36-pr. calibre, to fire across the Straits. (See Plan.) The 24-pr. guns were mounted on traversing platforms *en barbette*, over a 7 feet parapet. This heavy ordnance placed in battery was independent of the field artillery, horsed and perfectly equipped in reserve in Messina, consisting of three brigades of six pieces each, in excellent order in every respect.

The batteries placed at the salient points of the coast, were all open batteries, with parapets of earth, interior revetment of stone or brick, banquettes, curbs and pivots of masonry. Two only were supported by towers, as keeps, each mounting a carronade.

Every regiment, posted for the defence of a particular line of coast, provided for its security, by throwing up an epaulement in its own front, for protection against a cannonade from the enemy's gun-boats. The rear was cleared to afford ample space for the regiment to parade under arms. Here, every night during the three summer months, it was fixed until dawn, when there was light to see whether the enemy's boats were launched, and when found otherwise, the men marched to their encampments, and took such repose as was necessary during the day.

This precaution was essential, the distance across being so short, that a debarkation could have been effected before the troops were under arms; and flanked as these epaulements were by heavy artillery, a debarkation, with the arrangements described, seemed impracticable, and in fact was never attempted.

The coast, for about 20 miles, as shown in the plan, was perfectibly accessible in every part, with sufficient depth of water, and a rise and fall of tide of 3 feet; hence the only impediment to the landing of an enemy in force, were the precautions taken of having a body of troops on the spot, flanked by the coast batteries to keep him in check, and a sufficient reserve of all arms ready to support it.

In the event of a successful debarkation being effected by surprise or open force, roads of communication were made, so that the troops which might be separated from the line of retreat, or the intrenched camp, alluded to by Sir Alexander Bryce, had the means of retreating to the mountains or heights parallel to the sea-shore, and thus offer a second line of resistance in the works thrown up, as shown on the plan.

The engineering resources consisted of a detachment of British sappers and miners, a Maltese company of the same force, and a small staff of Sicilian civilians organised as overseers, &c. The native artificers were good, as the beautiful city of Messina could testify. The engineering tools and stores were English, of which there was an ample supply, and about fifteen officers of British engineers superintended the several works.

The citadel of Messina is a hexagon of entire masonry, casemated throughout. The land front has counterguards with casemated flanks, corresponding with what is termed Vauban's Third System of Fortification, and deep wet ditches, the tide flowing through them from the harbour to the sea. There is excellent bomb-proof cover for 2000 men, besides hospital, stores, and magazines. Five of the fronts have a fausse braye. The casemates appropriated to barracks are wide, lofty rooms, with semicircular arches, and well ventilated; and the interior space of the hexagon is unincumbered with buildings of any sort.

Notwithstanding the disadvantage of being commanded at the distance of 1200 yards, and of having large substantial buildings within 500 yards, the citadel of Messina stood two sieges, in the War of Succession, of sixty days each, about the middle and early part of the 18th century. And this work certainly saved Sicily to the present Neapolitan government in the late insurrection of that island, having a safe and easy communication from the sea.

The object of the author, in framing this paper, has been to show the great difficulty of effecting the debarkation of a considerable body of troops, when opposed on landing, if those precautions are taken, adopted in Sicily, of throwing up a breast-work to secure the troops from a cannonade, which usually cover the boats as they approach the shore, and placing the defence batteries on the salient points to play upon the flotilla in its advance; and on touching land, to prevent the enemy forming by repeated charges of cavalry and infantry; for no creature can be more helpless than the soldier when he scrambles out of his boat up to his waist in water, under a heavy fire of musketry, the flotilla probably in confusion by many of the vessels being damaged by the fire of the artillery, first with cannon shot, and then with grape and canister.

It has been stated in the 8th paper of the second volume of Professional Papers, New Series, that with the facilities given by railroads running parallel and near the shore, a body of troops could always anticipate an attempt to land, and be ready to oppose an enemy; and as it seems impossible that a naval armament can be of that light nature to run on shore at once, but must anchor and then prepare for debarkation by the use of boats, there is sufficient time for the opposing force to move from the railroad carriages to the beach, and there construct the necessary cover for its artillery, cavalry, and infantry.

It is likewise considered that the experience gained in the attempt against Sicily, and many other cases, shows that no country open to invasion can depend wholly upon its naval force, even if a supremacy at sea was a matter of certainty; and every nation must depend upon its land forces, and not upon the capriciousness of the winds and the waves.

Hence it has been suggested, that a few posts ought to be established on the southern coast of England, with barracks, stores, and railway carriages, from whence the garrisons might be conveyed by rail to the points threatened, and thus render expensive fortification unnecessary; and it has been stated that, a fleet hovering upon the coast, and threatening to land a force, must anchor, prepare their boats, and make such preliminary arrangements, as will give time to the garrisons of the several posts to prepare to resist a disembarkation.

And if there was any uncertainty when the attack would be made, the railway carriages may move as the hostile fleet moves, and the troops march to the shore when the fleet has anchored.

Consequently no large force ought to take the country by surprise, and a small one would be overpowered at once; and hence it has been assumed, with the precautions recommended, and an adequate land* force to meet any danger, an attack on the English shore will never be attempted. G. G. L.

J Bridges.

THE FARO AND COAST OF CALABRIA
FROM THE TOWN OF MESSINA

* Many persons may remember General Moore's Brigade at Shorn Cliff, in the years 1804-5, which became the Light Division in the Peninsular War. This brigade was organised as a moveable force for the protection of the coast of Kent, then threatened by invasion from the opposite shores of France; and by its equipment, discipline, and tactical instruction as light infantry, was rendered peculiarly efficient by its readiness to move at a moment's warning.

The adaptation of steam to navigation has now placed the whole of the south coast of England under similar circumstances to Calais and Boulogne, should war be declared with France. Instead of one post, like Shorn Cliff, it is proposed to have six, and organize a similar force to General Moore's, of all arms, ready and accustomed to move together, either on railway carriages laterally, or by marching to the sea-shore and prepare for defence.

The suggestion of brigading the troops, and consequently augmenting the land forces, and preparing quarters and railway carriages, has been repeated in this article for the observation of non-military readers, to induce the sanction of the necessary outlay before the danger occurs; for no preparation is requisite on the other side of the water when once hostilities are decided upon.

And the means suggested, if prepared beforehand, will certainly prevent any successful invasion on the shores of the British Channel; the more distant shores must be left to the co-operation of the naval forces, but the south coast would require no other protection than the moveable brigades, with suitable defences for the security of the harbours.

# PAPER XIII.

## Memoir on the Polygonal Fortification constructed in Germany since 1815. By A. Mangin, Capitaine du Genie. Translated by Captain J. Williams, R.E. With Notes.

A work was published during the last year, in Paris, under the authority of the Minister of War, written by Captain Mangin, of the French Engineers, entitled "Mémoire sur la Fortification Polygonale construites en Allemagne depuis 1815." The object of the Author is to show the little value of these fortresses by directing imaginary attacks against them, agreeably to the rules laid down by M. Fourcroy with the view of testing their absolute force.

The attacks are directed ostensibly:—1st., Against a salient having on one side a front of Germersheim, a Bavarian fortress, on the Rhine, and on the others a fort of Fort Alexander, at Coblenz (*See* plate, fig. 1). The fronts are assumed to be composed of a simple enceinte, flanked by a central caponnière which is covered by a small ravelin, detached escarp, and a glacis *en contrepente.* 2., Against the same fronts strengthened by counterguards (*See* plate, fig. 2). It must be observed, however, that the first supposition does not accord with the trace of Germersheim, nor is the trace of Fort Alexander correctly given in fig. 1. The front of Fort Alexander is essentially composed of the double enceinte, —the inner enceinte flanked by caponnières, and a glacis *en contrepente,* represented in fig. 2 of the plate. But it must be borne in mind that, from advantages of position, it would be impossible to breach from a distance the caponnière that flanks the only front of this work that can be attacked, nor to ricochet the same front, and that these advantages would greatly modify the attack.

It would be inferred from the general tenor of M. Mangin's remarks that the omission of the covered way and revetted counterscarp was a general feature in the fortresses lately constructed in Germany. This supposition, however, it is considered, would be incorrect. It is considered also that, in by far the majority of cases, the revetments of the new fortresses in place of being detached walls, would be found retaining revetments, built *en decharge* or counterarched. It does not seem a fair mode of testing the value of the polygonal system to take the trace M. Mangin has selected, and which must be considered to be a defective type of the original, and then to infer from its inferior power of defence that the whole system should be peremptorily rejected. It is considered, however, that the work of M. Mangin is both interesting and instructive, and a translation of a portion of it is given in the following paper:—

From the time that Vauban, by the organization of parallels, and by the introduction of ricochet fire, brought the art of attack to its present perfection, the defects of the bastion system have been insisted on by many engineers.

OBSERVATIONS.

*h heights over the Lakes is provided with reverse casemated Flanks*
*of Artillery and 250 Men.*
*Contour of the heights and that which crosses the Isthmus are pre-*
*lition to the heavy Guns indicated in the Plan.*
*s also been provided with reversed Flanks in the Counter carp*
*g into the round Lake is intended to afford shelter for the*
*s.*

Even Vauban himself seems to have been the first to have acknowledged that some modifications in that system were necessary, as in the later works which he constructed at Belfort, Landau, and Neuf Brisach, he departed considerably from the dispositions which he had at first adopted.

His example, nevertheless, was not followed by his successors; Cormontaingne and his school, instead of improving on the last systems of Vauban, adopted his first trace, and applied themselves to the improvements of the outworks, by constructing a redoubt in the re-entering place of arms, by augmenting the saliency of the ravelins, and by a few other details.

It must be, however, admitted that these improvements, valuable as they are in themselves, are not commensurate with the progress made in the attack; nor do they introduce into the defence any power which can at all neutralize the organization of parallels and the employment of ricochet fire. The imperfections which notwithstanding Cormontaingne's improvements still belong to the bastion system, have had so much weight with some engineers, as to induce them to reject the bastion system altogether. The defects more particularly chargeable on the bastion trace, and which those engineers who disapprove of it propose to rectify, are the following :—

1. It neither offers on the ramparts, nor in the interior of the place, protection against vertical or ricochet fire.

2. This latter fire takes in reverse the flanks and renders them untenable; although those flanks are the very lines from which are derived the peculiar advantages of the bastion trace.

3. The communications with the country and with the outworks are badly arranged, and are unfavourable for sorties.

4. The ditches of the outworks lay open the escarp of the body of the place down which the besieger can breach the wall before he has crowned the covered way.

5. The parapets are defectively supported, inasmuch as they are brought down by the fall of the escarp.

6. Interior retrenchments do not form an original part of the system, and are difficult to construct during the time of siege.

7. The operations necessary to place the fortress in a state of defence, and to maintain it so during the siege, are difficult to execute, and cause much fatigue to the garrison (palisades, tambours, retrenchments).*

Among the detractors of the ancient fortification who have more particularly insisted on the defects we have enumerated, Montalembert and Carnot are among the most eminent. Condemning the systems hitherto adopted, they reproached the French engineers with not having placed the defence on an equality with the attack, and asserted that this equality can only be attained in making a radical change in the bastion system both in its trace and relief.

Montalembert considered that the artillery of the fortress should always preponderate over that of the attack, and for the purpose of protecting this artillery, he proposed to construct caponnières or casemated bastions, situated in the middle of the front to be defended, and containing several stages of bomb-proofs protecting an overwhelming armament of artillery and gunners from vertical and ricochet fire; he considered, therefore, that this artillery would remain uninjured till the conclusion of the siege, and that the besieger, in presence of so

* *Remark.*—To these may be added that it does not apply itself readily to the ground. *Translator.*

formidable a fire, would neither be able to establish his counter nor breaching batteries, nor make the passage of the ditch.

The introduction of these caponnières with their sweeping fire would dispense for their mutual defence with the separation of the flanks by a curtain, and thus the bastion trace no longer became necessary.

With regard to the profile, Montalembert made marked modifications: in the greater number of his projects he employed detached escarps and added casemates to them, so that, not only in the caponnières but also in the body of the place, the artillery was protected from ricochet fire.

Carnot, while he adopted many of Montalembert's modifications, founded his system of defence on quite another principle. He proposed to annihilate the besieger, should he venture to approach the glacis, by an overwhelming vertical fire. The besieger's operations would become, if not impossible, at least so perilous as to expose him to enormous losses. If to avoid these losses, the besieger retired the guards of the trenches; and but weakly supported the heads of his attack, then frequent sorties would destroy the *boyaux* and kill the working parties.

To secure the continuance of vertical fire, Carnot established in rear of the body of the place, casemates open at each end, in which the mortars and artillery-men were protected from the missiles of the besieger.

To facilitate sorties, Carnot cleared away all obstacles between the enceinte and the besiegers' approaches, and therefore did away with the counterscarps and glacis, replacing them by a glacis "en contrepente," which permitted the troops of all arms to pass rapidly from the ditch to the country.

To prevent the besieger also from ruining the parapet at the same time that he breached the revetment, Carnot detached the latter from the parapet, gave it a defensive profile by piercing it with loop-holes, and thus obtaining a *rasante* fire, he was enabled, like Montalembert, to renounce the bastion system.

The trace Carnot seemed to prefer was the *tenaille* form, which had been some time previously proposed both by Montalembert and former engineers, based however on a different principle.

The suppression of the counterscarp and covered way obliged Carnot to cover his scarps by earthen counterguards, which were not, however, like the body of the place, defended by escarps, and thence arose dead angles which rendered the system defective.

Such is the spirit of Montalembert and Carnot's systems; they have been totally rejected in France, while the German engineers, selecting and combining portions of each, have introduced a mixed system which has been employed in the construction of the fortresses in Germany built since 1815. Their trace, as borrowed from Montalembert, is nearly as follows:—

On an exterior side of about 547 yards a caponnière is placed, whose flanks have a saliency of 33 yards, and whose faces intersect at an angle a little larger than 60°. These faces are themselves defended by two other flanks, or brisures, placed in the body of the place, and united by a sort of curtain. The above disposition forms the trace of the body of the place.

As to the caponnière, sometimes it is connected with the body of the place by the prolongation of the flanks, or it is closed at the gorge, and is detached from the enceinte; or otherwise it is connected by a wall with the batteries which flank their salients.

A counter-guard or ravelin is usually placed in advance of the caponnière, whose branches terminate at the main ditch; sometimes, also, a similar

Even Vauban himself seems to have been the first to have acknowledged that some modifications in that system were necessary, as in the later works which he constructed at Belfort, Landau, and Neuf Brisach, he departed considerably from the dispositions which he had at first adopted.

His example, nevertheless, was not followed by his successors; Cormontaingne and his school, instead of improving on the last systems of Vauban, adopted his first trace, and applied themselves to the improvements of the outworks, by constructing a redoubt in the re-entering place of arms, by augmenting the saliency of the ravelins, and by a few other details.

It must be, however, admitted that these improvements, valuable as they are in themselves, are not commensurate with the progress made in the attack; nor do they introduce into the defence any power which can at all neutralize the organization of parallels and the employment of ricochet fire. The imperfections which notwithstanding Cormontaingne's improvements still belong to the bastion system, have had so much weight with some engineers, as to induce them to reject the bastion system altogether. The defects more particularly chargeable on the bastion trace, and which those engineers who disapprove of it propose to rectify, are the following :—

1. It neither offers on the ramparts, nor in the interior of the place, protection against vertical or ricochet fire.

2. This latter fire takes in reverse the flanks and renders them untenable; although those flanks are the very lines from which are derived the peculiar advantages of the bastion trace.

3. The communications with the country and with the outworks are badly arranged, and are unfavourable for sorties.

4. The ditches of the outworks lay open the escarp of the body of the place down which the besieger can breach the wall before he has crowned the covered way.

5. The parapets are defectively supported, inasmuch as they are brought down by the fall of the escarp.

6. Interior retrenchments do not form an original part of the system, and are difficult to construct during the time of siege.

7. The operations necessary to place the fortress in a state of defence, and to maintain it so during the siege, are difficult to execute, and cause much fatigue to the garrison (palisades, tambours, retrenchments).*

Among the detractors of the ancient fortification who have more particularly insisted on the defects we have enumerated, Montalembert and Carnot are among the most eminent. Condemning the systems hitherto adopted, they reproached the French engineers with not having placed the defence on an equality with the attack, and asserted that this equality can only be attained in making a radical change in the bastion system both in its trace and relief.

Montalembert considered that the artillery of the fortress should always preponderate over that of the attack, and for the purpose of protecting this artillery, he proposed to construct caponnières or casemated bastions, situated in the middle of the front to be defended, and containing several stages of bomb-proofs protecting an overwhelming armament of artillery and gunners from vertical and ricochet fire; he considered, therefore, that this artillery would remain uninjured till the conclusion of the siege, and that the besieger, in presence of so

* *Remark.*—To these may be added that it does not apply itself readily to the ground. *Translator.*

formidable a fire, would neither be able to establish his counter nor breaching batteries, nor make the passage of the ditch.

The introduction of these caponnières with their sweeping fire would dispense for their mutual defence with the separation of the flanks by a curtain, and thus the bastion trace no longer became necessary.

With regard to the profile, Montalembert made marked modifications: in the greater number of his projects he employed detached escarps and added casemates to them, so that, not only in the caponnières but also in the body of the place, the artillery was protected from ricochet fire.

Carnot, while he adopted many of Montalembert's modifications, founded his system of defence on quite another principle. He proposed to annihilate the besieger, should he venture to approach the glacis, by an overwhelming vertical fire. The besieger's operations would become, if not impossible, at least so perilous as to expose him to enormous losses. If to avoid these losses, the besieger retired the guards of the trenches; and but weakly supported the heads of his attack, then frequent sorties would destroy the *boyaux* and kill the working parties.

To secure the continuance of vertical fire, Carnot established in rear of the body of the place, casemates open at each end, in which the mortars and artillerymen were protected from the missiles of the besieger.

To facilitate sorties, Carnot cleared away all obstacles between the enceinte and the besiegers' approaches, and therefore did away with the counterscarps and glacis, replacing them by a glacis "en contrepente," which permitted the troops of all arms to pass rapidly from the ditch to the country.

To prevent the besieger also from ruining the parapet at the same time that he breached the revetment, Carnot detached the latter from the parapet, gave it a defensive profile by piercing it with loop-holes, and thus obtaining a *rasante* fire, he was enabled, like Montalembert, to renounce the bastion system.

The trace Carnot seemed to prefer was the *tenaille* form, which had been some time previously proposed both by Montalembert and former engineers, based however on a different principle.

The suppression of the counterscarp and covered way obliged Carnot to cover his scarps by earthen counterguards, which were not, however, like the body of the place, defended by escarps, and thence arose dead angles which rendered the system defective.

Such is the spirit of Montalembert and Carnot's systems; they have been totally rejected in France, while the German engineers, selecting and combining portions of each, have introduced a mixed system which has been employed in the construction of the fortresses in Germany built since 1815. Their trace, as borrowed from Montalembert, is nearly as follows :—

On an exterior side of about 547 yards a caponnière is placed, whose flanks have a saliency of 33 yards, and whose faces intersect at an angle a little larger than 60°. These faces are themselves defended by two other flanks, or brisures, placed in the body of the place, and united by a sort of curtain. The above disposition forms the trace of the body of the place.

As to the caponnière, sometimes it is connected with the body of the place by the prolongation of the flanks, or it is closed at the gorge, and is detached from the enceinte; or otherwise it is connected by a wall with the batteries which flank their salients.

A counter-guard or ravelin is usually placed in advance of the caponnière, whose branches terminate at the main ditch; sometimes, also, a similar counterguard covers the angle of the polygon: occasionally this latter work is omitted, and a casemated redoubt occupies the re-entering formed by the ravelin and the body of the place.

In these different traces, a casemated traverse shuts the opening which is formed by the ditches of the outworks.

Lastly, in some fortresses beyond the ditch, in place of a counterscarp and a covered way, a glacis "en contrepente" is substituted; to which is added, at the roundings opposite the salients, a small redoubt, intended to defend the ditch, and to give access to the galleries of mines.*

In the interior, the casemates proposed by Carnot, are introduced to protect the mortars, and to secure the continuance of the vertical fire. Occasionally, however, in place of establishing special casemates to receive these mortars, the German engineers place them in the caponnière which defends the ditch, or towards the salients of the fronts, in batteries conveniently arranged for the purpose. Thus, at Germersheim, the escarp gallery is detached from the revetment, and forms at the salient a court 23 yards by 7 yards, on which open five casemated mortar batteries. The detached escarp in front of the mortar casemates is crenelled, and a postern leads into the interior of the place. Two powder magazines are situated on either side of the postern, the walls of which being raised above the rampart, form the sides of a small bomb-proof battery capable of covering three guns, while at the same time it acts as a traverse. In Germersheim there are also other batteries on the ramparts of the same description, placed near the angle of the shoulder; but in these positions they are preceded by a ditch on the side of the salient, thus forming a coupure for a retrenchment. (Fig. 1, dotted lines, *saillants*, B and C.) The height of these small casemates, or hollow traverses, is about 7 feet above the adjacent traverses.

The profiles of Carnot's system have been employed, consisting of a detached escarp and chemin de ronde. Nevertheless, in some of the fortresses recently constructed—in Germersheim for instance—the detached revetment has been abandoned, and a revetment "en décharge," or counterarched revetment has been substituted in its place.†

As to the caponnière on which the flanking of the fronts depends, it is composed of one or two stories of casemates, each being about 28 feet long and 16 feet broad. Those in the flanks which sweep the ditch are intended for artillery, while those on the faces are confined to musketry. The casemate on the salient frequently contains a mortar. To allow of vertical fire, the casemate instead of being brought up to the exterior wall of the caponnière, has in its front a small triangular space by means of which the mortar placed in the casemate is able to maintain its fire. Sometimes, as already described, a similar arrangement is made at the salients of the body of the place.

All the casemates of the caponnière open on an interior court more or less spacious (16 yards by 21 yards), in order to facilitate the escape of the smoke. The floor of the casemates, as also that of the chemin de ronde, is placed about 6 or 7 feet above the bottom of the ditch. The glacis is raised sufficiently high to cover the masonry. The construction, however, given above, principally taken

* Many improvements have been introduced by the German engineers into the trace described by Captain Mangin, which, indeed, cannot be considered to represent the polygonal trace as employed by them, more than the trace of Errard or his contemporaries represent the present bastion system.—*Tr.*

† This construction, it is considered, has been adopted in the greater part of the fortresses recently constructed in Germany.—*Tr.*

from Coblentz and Germersheim, does not apply in its details to all the fortresses recently constructed: these details, however, do but affect in a very secondary manner, the efficiency of that system whose value we are about to test.

The method which we shall adopt will consist in following in detail the march of the attack directed against this new system of fortification, and in comparing the difficulties it would meet with those experienced in the attack against the bastion system, we shall discuss the principles of each in the order which they may present themselves. We shall suppose, in order that the conditions may be similar to those which might be expected in a siege, that our attack is directed against a marked salient; as for example, that of a hexagon whose opening is equal to the mean of the angles attacked in more than sixty sieges, the plans of which we have examined.

We shall adopt on one side of the salient the trace of Germersheim (fig. 1), and on the other the trace of the enceinte of Fort Alexander at Coblentz; * nevertheless, in this latter trace we shall suppose that the traverses which close the openings of the ditches of the ravelins, are connected with the casemated redoubts established in the re-entering angles, as at Germersheim. These redoubts are replaced at Fort Alexander by counterguards, which cover completely the body of the place, and which form as it were the first enceinte; but these counterguards cannot be considered as forming an essential element in the polygonal fortification; they have been established at Fort Alexander to give to it the degree of force which its importance demands, since it is the key to the whole position. We shall return, at a subsequent period, to the attack of those fronts which are furnished with these additional works.

The early stage of the attack, against the system we have described, would be executed in the ordinary manner. No loss nor inconvenience would be experienced from the guns in the casemates, which have no direct action on the country, and which could not see the works of the besieger till he had crowned the glacis. The approaches previously to the crowning would only be exposed to the artillery on the ramparts, as in ordinary attacks; indeed it will be seen, there is less to fear from cross fire than from the ancient trace.

Montalembert maintains that the polygonal system allows of a larger force of artillery being placed on the ramparts than the bastion system does, and that it obliges the besieger to give a greater development to his works, in order to embrace the front of attack. It is easy, however, to see that these advantages are but small. Thus, in the example we have chosen (fig. 1, pl. 1), we can nominally place on the ramparts of the polygonal trace, 390 † pieces of ordnance at a maximum, which would see the batteries of the besieger. In the bastion trace, passing through the same salients, 260 guns could only be placed in battery fulfilling the same conditions; but this last armament is already on so great a

* It has been already stated that the traces given in fig. 1 of the plate do not represent Germersheim nor Fort Alexander, although both these fortresses are constructed essentially on the polygonal system. Germersheim on its principal fronts has its escarp constructed *en decharge*: it has also a covered way with glacis, with reveted counterscarps in stone (the escarp being composed of brick) and a masonry rebuilt in the re-entering place of arms. The faces of the ravelins are flanked by 3-gun casemated batteries closing their ditches, but not connected with the redoubts in the re-entering place of arms. Fort Alexander is composed of double enceinte, the detached escarp being protected by a counterguard agreeably to the profiles of Carnot. (See Papers connected with the duties of Royal Engineers, vol. 2.) M. Mangin's attacks, therefore, must be considered directed against an assumed system rather than against the particular fronts alluded to.—*Tr.*

† This appears an excessive armament.—*Tr.*

scale as not to be realised in any siege; in fact, it would be necessary in order to construct the embrasures, platforms, &c., which such an amount of artillery would require, and to man the guns, to maintain such a garrison, and to collect such a matériel, as would far exceed the ordinary resources of the state; the reasonings then of Montalembert are nothing more than abstractions, without value in a practical view, and may be fairly met by asserting that the attack is equally susceptible of increasing its resources as the defence; besides, it has the advantage of being able to renew them, as well as the power of employing them in a more efficacious manner by directing against the place a converging fire, from which arises its uniform superiority.

With regard to the extension of the works of attack resulting from the trace of the fronts, we shall remark that the extension does not apply to the zig-zags, which are difficult of execution, but only to the parallels which would require to be a little longer than in the bastion trace. But considering the mode of executing these works, such an augmentation (870 yards for the second parallel, and 164 yards for the third) would not, in a well-conducted siege, retard the progress of the attack by a single day.

The extension,* it is true, would oblige the besieger to spread his force over a greater space, or to strengthen his guard of the trenches; perhaps he would find it advisable not to ricochet the collateral faces, in order to shorten by 450 yards the length of his parallels. But in this case the flanks of his attack would be more exposed, than when he both ricocheted and counterbattered all the faces which bear on the ground, over which the attack is carried; but whichever alternative he might adopt, while, on the one hand, it is conceded that the besieger would experience before the polygonal system a little more difficulty than before the bastion system; on the other hand, these difficulties appear so unimportant that they would not cause any delay in the progress of the attack.

The second parallel then would be traced and commenced 327 yards from the most advanced saillants on the third night, and completed on the night following.

The fourth day the direct and ricochet batteries would be traced; the besieged being unable to direct against them a more powerful fire than usual, they would be completed in thirty-six hours; they would be ready to open their fire on the morning of the sixth day.†

* If the besieger's battery were placed at the flank of the extended parallel, would it not be brought under the fire of the collateral faces of the fortress, which being unopposed would silence the battery?—*Tr.*

† It is a question whether a besieger would succeed without great loss in time and men, in establishing his first batteries at 327 yards from the most advanced salients, if the ramparts were armed with an effective artillery. It is not till the third night after breaking ground that the second parallel is executed, and thus time would be given to the garrison fully to arm the fronts of attack, as well as the collateral fronts. The position of the besieger's batteries being known, the garrison could not fail to discover the precise moment at which they were commenced, and would direct such a destructive fire of grape and case shot upon the working parties, as must prove disastrous to the besieger, if it did not compel a cessation of the work. The batteries would be within point-blank of large howitzers (8 in. and 10 in.); the ramparts are unmolested, and under such favourable circumstances every shell fired from such pieces by the besieger must hit the besieger's batteries and produce its effect. It is related in the valuable record of the Sieges of the Peninsula, bequeathed to us by Major-General Sir John Jones, that at the siege of Ciudad Rodrigo the besieger's batteries occupied an unusual length of time in throwing up, in consequence of the enemy's directing against them an incessant fire of shells filled with powder; three or four of such missiles it would appear, occasionally exploded in the middle of the parapet of a battery in the course of an hour, each having the effect of a small mine, and scattering the earth in every direction. Now it must be borne in mind that the formidable result above described was produced by vertical fire: the chance of the shell being lodged on the

In our project of attack there is nothing extraordinary or unusual in the composition of these batteries; but in general it may be remarked that it is not necessary to ricochet the covered way, since this outwork does not exist, although batteries will be found in the prolongation of the ditches of the enceinte and of the ravelin. We shall now explain the reasons which influence their position, and the effects which may be expected from them.

The batteries established against the caponnières are about 660 yards from them, which is the point-blank range of guns of large calibre when laid by the line of metal.* But we know that in a gun fired under such circumstances, the projectile first rises above the line of metal, attains the culminating point of its path, and then descends and strikes the object precisely at the point where it again intersects the metal line of the gun prolonged. If between the object and the mouth of the gun a glacis is interposed, whose crest is not elevated above the path described by the projectile, it is clear that nothing would be changed in the effect of the fire described above; it would be a direct fire;* although the object fired at not being visible would give it the appearance of ricochet fire. But from a consideration of the data, combined with artillery experiments (*Aide-Mémoire*, 1844, page 412), it appears that the caponnière to be breached, the crest of the glacis, and the battery established in the second parallel, precisely answer to the conditions implied in the hypothesis. The effect of these batteries will, therefore, be the same as if the wall were exposed at a distance of 660 yards. But under such circumstances the penetration of 16 and 24-pounders shot into good masonry, is from 10 to 12 inches. Such a fire, prolonged a short time, will soon ruin the exterior wall of the caponnière, already weakened by its embrasures.

On this point experience verifies theory; the history of sieges furnishes numerous examples of breaches opened at this distance in walls much more solid than those under consideration; breaches which might not have been practicable, but which still prove the facility of destroying masonry at a distance, which is the point here contended for.

This result appears so much the more certain, since the caponnière cannot escape receiving the whole of the fire directed against it. The main ditch is 32 yards wide; the base of the slope of the glacis *en contrepente* is 22 yards wide, and all the shot which struck it would, from its inclination, be deflected inwards: the breadth of the ditch may, therefore, be taken as if it were in reality 54 yards wide, forming an opening on a caponnière whose height does not exceed 30 feet.

parapet of the besieger's battery being most uncertain. But in a direct fire from, say a 10 inch howitzer, placed at point-blank range at the object fired at, every shell would be buried in the massive parapet of the besieger's batteries, and in place of three or four shells per hour, six times that number from a single gun would be lodged there. Indeed the power of projecting large shells horizontally must greatly retard the establishment of the besieger's front batteries, and it is considered of great advantage to the defence. The only siege that has occurred since the power of throwing large shells has been obtained, or at least used, has been the siege of Antwerp, and in this siege this nature of fire was not employed.—*Tr.*

* Portée de but en blanc des pièces de gros calibre. See English *Aide-Mémoire*, vol. iii. p. 122, Article, Point-blank.

"But en blanc naturel, ou singlement but en blanc, la plus eloigné des deux points de rencontre de la trajectoire avec la ligne de mire naturelle. Portée de but en blanc, distance du but en blanc à la bouche de la pièce." Colonel Dundas observes "the but en blanc in French nomenclature is the range of the projectile from a gun laid with the line of metal elevation or angle de mire, 800 yards being given as the range with that elevation, and one third the weight of shot in powder as the charge: it is presumed that the dispart (Anglicè) of the gun is about 1°, which makes the power of the 30-pr. French and 32-pr. English nearly equal. In the French service the tangent scale, or the *hausse*, is divided for distances, and not for any definite angle."

It would be impossible for artillery, even when badly served, to miss an object placed under such circumstances.

All the shot then fired by the besieger would strike the face of the caponnière with a momentum due to line of metal range, which already weakened by embrasure would soon be infallibly ruined;* after which, traversing the caponnière, they would take in reverse the artillery and the defenders of the opposite flank, splintering the masonry, and rendering the work entirely untenable. We do not doubt that the place would be deprived of flanking defence from an early period of the siege, and be exposed to all the danger such a serious defect occasions.

The fire from the ricochet batteries would have also another effect still more disastrous to the defenders. Experiments made in England have shown, that the detached escarp of Carnot can be breached even almost to their foot by ricochet fire. We shall cite here the results of these experiments, in order that we may more fully appreciate their important bearing on this new description of fortification.†

Carnot's wall, against which the experiments were directed, was 30 feet long and 20 feet high; its thickness at top was 6 feet and 8 feet at the base; at each extremity it was strengthened by a counterfort 4 feet square, which made its whole length equal to 30 feet.

An earthen counterguard was placed in front of this wall, the crest of which was as high as the revetment, and 60 feet from it. In rear, an earthen mass, preceded by a *chemin de ronde*, represented the main work, and rose 5 feet above the summit of the wall.

This wall which had been carefully constructed, was exposed a year after it was built to the fire of two batteries, one of which was armed with eight 68-pounder carronades, placed at a distance of five hundred yards from the crest of the counterguard, and the other armed with three 8-inch, and with three 10-inch howitzers, at a distance of four hundred yards. In six hours each gun had fired 100 rounds—making a total of 1400 rounds,‡ the carronades throwing

* We believe, in practice, it would be found a very long and difficult operation to silence the caponnière in the manner proposed by Captain Mangin. It must be remembered that the piers of the casemates, extending 30 feet backwards from the wall, and presenting their ends to the besieger, are not more than 12 or 14 feet apart. How would it be possible, without enormous firing, to ruin these piers concealed from the battery by the intervening glacis? Should the besieger succeed in damaging the mur de masque or front wall of the caponnière between the piers, in which the embrasures are pierced, the defenders have still the power of rendering the work secure from assault and capable of defence. In the construction of the caponnière provision is always made for barricading the front wall in the event of its being breached; and thus flank defence would still be preserved for the defence of the ditch.

It should also be remarked, that by breaking the side of the polygon, so as to form a very obtuse salient angle at the position of the caponnière, the difficulty of taking up the prolongation of the ditch is greatly increased, if not altogether prevented. This arrangement has been adopted at Radstadt. See Captain Meurice de Sellon's work on that fortress.

† See Vol. 2 of "Professional Papers," and Vol. 2 of "Aide-Mémoire."

‡ The effect seems hardly commensurate with such an expenditure of ammunition, and in the siege under consideration, it would appear more advisable to await the crowning of the glacis previously to establishing the breaching batteries.

With respect to detached escarps covered by counter-guards, the besieger might accidentally succeed in establishing, at a great cost of ammunition, a small breach in them from batteries in the second parallel. The experiment at Woolwich, in 1824, certainly tends to show that such an operation is practicable, although the conditions under which the wall was destroyed in the experiment will not bear a parallel with those which must exist in an actual siege. But the attack on such a breach from a distance must be considered a dangerous movement, as the garrison would have the power of barricading and closing by various solid shot, and the howitzers loaded shells. The wall was then examined, and was found to present a practicable breach 14 feet wide; the counterforts also were much shaken.

The next day the firing was resumed with thirteen pieces during two hours, and after an expenditure of 50 rounds per gun—or 650 in all, the breach became perfectly practicable and the counterforts were almost destroyed. The rubbish was then cleared from the wall, and 5 feet of it were found still standing.

In conclusion, to show more conclusively the effect of plunging fire against naked walls, the next day the cannonade was recommenced, and 1100 rounds were fired in three hours, and reduced the remainder of the wall to a heap of ruins, in spite of the counterguard which protected it.

The above experiment shows the weakness of detached revetments, since it proves that they can be destroyed rapidly by a battery at a greater distance from them than the second parallel is usually traced. Here the fire was highly inclined, more particularly towards the closing of the experiment, when it became necessary to elevate the gun considerably in order to strike the wall, which was only 5 feet high. In the fortification which forms the subject of the present consideration, the crest of the glacis instead of being 60 feet from the escarp is 60 yards distant from it. The level of the besieger's batteries is much more elevated than in the experiment above recited; the fire will be therefore considerably less curved, and will therefore be much more effective.

There can be little doubt, then, that the fortress would be exposed from the earliest period of the siege to have its detached escarp and its flanking caponnière destroyed by the besieger's distant batteries—a most serious defect, which deprives the new system of what may be considered the most essential condition of fortification, that of not being taken by a *coup de main.** These defects, moreover, are the more serious, from the consideration of the mode in which they are brought about, viz., by distant parallels and batteries, easy to establish on every

obstacles a breach of 14 feet opening. Moreover a storming party who should attempt to assault such a breach before the lower guns of the caponnière were silenced, (and we do not think they could be silenced from the second parallel) must suffer great loss and be repulsed. The bottom of the ditch is swept by five guns, and it would be most hazardous for the besieger to venture into it. The loss of interior space caused by detached revetments, the little resistance they offer to the breaching batteries when established on the glacis, and the facilities in storming the breach, are the great defects of such an escarp, and we believe in the later constructions in Germany detached escarps have been abandoned.

Referring to the experiment at Woolwich in 1824, and to the conditions under which it was carried on, it is a question whether it would not have been advisable to have opened the counterguard from the shells of the 8 inch and 10 inch howitzers, and then to have breached the wall by a direct fire; no experiments have hitherto been made to ascertain the power of shells to open counterguards. Some information on this point is very desirable. Bousmand in his project of attack on Coehorn's first system, proposes breaking the earthen counterguards and lower faces of the ravelins and bastions by howitzers and mortars mounted so as to enable the besieger to fire them directly. He says, in speaking of the establishment of his first batteries in the crowning of the glacis, that as their fire must be directed in the first instance against earthen-works, viz., the counterguards and lower faces of bastions and ravelins, their armament should consist of howitzers and mortars mounted on gun-carriages (sur affects de canons). Each shell lodged in the counterguard would produce an effect of a small mire, varying according to the quantity of powder contained in the shell, less the quantity required to burst it. Thus the 12 inch shell containing 17lb. of powder, of which 5lb. is the bursting charge, would act as a mire loaded with 12lb. of powder, and assuming the shell to have a penetration of 5 feet, would produce by its explosion a crater of 10 feet diameter. In this way Bousmand computed that each discharge from a battery of large mortars would blow away 4 or 5 feet of the counterguard. Some experiment to ascertain the time and ammunition required to open earthen counterguards of different profiles are very desirable.

* There can be no doubt such protection on an open rampart is invaluable.—*Tr.*

front of the fortress. The besieger will not fail to avail himself of this power to open the enceinte at different points, and then the besieged would find himself exposed to a general assault, which could scarcely fail of success.

The power, also, of being able to breach the enceinte at any given point from a distance, renders nugatory the interior retrenchments, unless they receive a considerable development. In the ancient fortification interior retrenchments may be constructed in chosen positions with regard to those parts of the glacis which will be crowned by the besieger; but in the new system the point of attack is everywhere; and it would be necessary, therefore, to construct retrenchments to each front. In a small fort it is easy to conceive one central redoubt would be sufficient; but if the work had much development, to retrench it would be equivalent to constructing a second enceinte. It is stated, and with force, that the position of the wall in the experiment carried on at Woolwich was accurately known; and the effect of each shot being marked, an accuracy of fire was arrived at which would be impracticable to attain in practice. It is further objected that it would be necessary to reconnoitre the breach previously to giving the assault, and this would be impossible from the distant position of the besieger's works. This objection, to a certain degree, is well founded, if applied to Carnot's system, where the body of the place is concealed by counterguards, which might be strongly occupied until the besieger had taken them by regular approach; but the objection has no force when applied to an enceinte which has neither counterguard, nor reveted counterscarp, nor palisaded covered way. * The difficulty of reconnoitring a breach depends on the material obstacles of the resistance that would be found in approaching it. Here the obstacles have disappeared, and with them all possibility of organising any exterior resistance. The besieger finds himself only 330 or 440 yards from the ditch; and as only a few minutes would be required to clear this distance, he would be able, at any moment of the night, and without being exposed to a single shot, to close with the detachments of the garrison placed in advance; the casemated fire would not assist the latter, since its effects would be equally disastrous to both parties. Hence the ditch would offer no position for the besieger's advanced guards; and it may almost be said that he would not be able to place a single sentinel there, without the danger of his being carried off by the small detachments which the besieger would throw forward either for the purpose of reconnoitring the breach, or to alarm the garrison. Unless, then, the body of the place should be surrounded by exterior works, there would be no difficulty in the reconnoissance of the breach; a condition which limits singularly the employment of a glacis *en contrepente*. But under this hypothesis the breaches made in the detached escarps of the advanced works are of very serious moment to the besieged; their access not being defended by any material obstacle, the armament and the garrison of these advanced works are open to the assaults of the besieger, and must, therefore, be ready at all times to resist them, and is thus placed from the com-

* If the glacis be suppressed it will be necessary to supply its place by a counterguard, (which is admitted, indeed, to be an indifferent substitute,) otherwise the detached escarp would be exposed. Should the profile consist of a glacis, a covered way would be implied, although it might not be of normal dimensions; but it would afford an advanced position to the fortress, which would prevent access to the besieger into the ditch. In the plate to this paper, containing the project of attack, it will be observed that the glacis is figured 8 feet above the country, but its interior slope is brought into the same plane as the slope of the glacis en contrepente. We do not believe that the profiles of any of the works constructed in Germany since 1815 accord with the profile assumed in the plate.

mencement of the siege in a difficult and unquiet position. In short, rapid silencing of flanking fire, destruction of the escarp, composed, as it is, of a fragile wall; suppression of the obstacles which prevent the reconnoissance of a breach, and render its access difficult: all these defects combine in subjecting this system to be carried by the besieger immediately by assault.

Thus, in the greater part of the new constructions, the glacis *en contrepente* and the detached escarps have been given up: at Germersheim, for instance, the place is surrounded by a revetment *en décharge*, with a reveted counterscarp, and with a covered way; there remains in the new systems only the casemated caponnieres; and already is much anxiety felt from their exposure to the fire of the ricochet batteries. We are convinced that these works will be radically changed, and will have eventually the fate of the other innovations already abandoned.

The defects which we have commented upon are, in our opinion, fatal to the new system of fortification. We shall continue, however, our discussion of its properties in continuing the attack in advance of the second parallel; we shall thus have occasion to bring the foregoing defects into stronger light, and to point out others which were not so apparent in the rapid attack which we have described.

Let us first commence by completing the examination of the effects produced by the first ricochet batteries. We have seen what may be expected from them relatively to the masonry of the enceinte and caponnieres; let us see, now, what their effect will be on the earthen masses of the ramparts. Perhaps they will appear, in this point of view, less efficacious than in the bastion system. The salient angles are, in reality, more open than in the bastion trace, and it has been already remarked this circumstance would prevent the ricochet of the collateral faces of the front of attack, or otherwise would oblige the besieger to give a greater development to his parallels; the interior space is, besides, less limited; and also, in some places, the traverses or small bomb-proof buildings on the ramparts, guard better than ordinary traverses against the effect of ricochet. But, on the other hand, the lines to ricochet are longer, while the traverses, although more effective than those thrown up during the siege, yet, from their paucity and their little relief, leave pretty nearly the rampart under its usual condition. These traverses also are intended to protect a few guns; and if the latter were considerable, they might possibly be able to compete with the distant batteries of the besieger; but as these guns are extremely limited — 7 per front — the besieger, in directing against them a converging fire, would soon ruin the masonry cheeks of their embrasures and the front wall of the casemate. Under these circumstances, no great importance can be assigned to them. It is only when the artillery have abandoned them that they become really useful to the defence,* in affording to the troops who are upon the ramparts better cover than the blinds and other temporary works thrown up during the siege; and under this point of view, joined to the advantage they give of better protection against ricochet fire, it would be as well to adopt them more frequently, notwithstanding the expense of their construction.

In conclusion, the remaining advantage which is claimed for the Polygonal fortification is, that it has not flanks, which, like those of the bastion system diminish the interior space, while they are taken in reverse by the same fire which ricochets the adjoining face. This defect in the bastion trace, appears at first sight

* There can be no doubt, such protection on an open rampart, is invaluable.—Tr.

a very serious one; it is one of those on which the opposers of that system have chiefly dwelt. It is, however, sufficiently manifest, that if this defect operates disadvantageously towards the conclusion of the siege, it is scarcely felt at the commencement of its operations. The flanks have, in fact, little influence in the distant attack: the early batteries and approaches of the besieger must be opposed by the artillery of the faces of the bastion and of the ravelin, while it cannot be maintained that this artillery is at all more exposed by the existence of the flanks. The distant defence then will not be the less vigorous, and the bastion trace will not present less obstacles to the works of attack between the second parallel and the crest of the glacis, than the polygonal trace does.

Thus, then, between the fifth and sixth night, zig-zags in front of the second parallel would be executed in the usual manner; on the seventh night, the demi-places of arms would be commenced; on the eighth, the approaches would be continued, and on the ninth night the third parallel would be commenced at 55 or 65 yards from the crest of the glacis.

Thus far the approaches have been carried on in the ordinary way; but from this period of the siege, the attack is not in the same conditions as when directed against a bastion fortress; on the one hand, it sees before it a glacis *en contrepente* which is presumed to expose it to sorties, but then on the other, it has nothing to fear from a low and close fire from the covered way. It is necessary to examine then what will be the effect of this change.

And firstly, in regard to the fire of the covered way, it must be remarked that it is to this fire that must be attributed the slow advance of the attack in advance of the third parallel; up to this place of arms the besieger advances rapidly, and executes his approaches by the flying sap. But arrived at 65 yards from the salients of the glacis, obliged, as it were, to work under the eyes of the besieged, who can distinguish his movements and hear the noise of his tools, the attack necessarily is reduced to advance with caution, and must have recourse to the single sap. The covered way forms then a formidable position against the besieger and compels him to change entirely the nature of his attack, while it permits the garrison to commence an active struggle against an enemy superior in force. In suppressing this outwork, the musketry fire is retired 65 yards, while it is deprived of its sweeping property which is the chief cause of its efficacy; the besieger has no longer the means of closely watching the besieger, who would thus be enabled to crown the glacis by flying sap. An inspection of fig. 3 will show that there is nothing exaggerated in what is here advanced. In the first place, the third parallel is placed more than 130 yards further from the salients it is intended to envelope. The approaches also in front of this parallel are 82 yards, removed from the salient when they arrive at the crest of the glacis, and at this distance, greater than that which usually separates the third parallel from the covered way, means have always been found to employ the flying sap, or at all events, the regular sap can be so accelerated as to progress almost at the same rate. In this instance the acceleration would be the more practicable, since there is scarcely anything to fear from the fire of the works, against which the approaches are directed—their faces, in fact, make too acute an angle with the capital to allow of any fire in the direction of the latter, and the fire of the collateral works is 240 yards distant from the heads of the attack; the approaches are then exposed to no other musketry fire than that proceeding from the *pan coupé* usually placed at the salient of each work. This latter is not a formidable obstacle, but it forms the only musketry defence received by the glacis; yet the German engineers have not hesitated to substitute this defence for that afforded to the raking fire of a covered way, which costs nothing, and whose trace throws a converging fire on the heads of the attack. If such a transformation does not greatly accelerate the attack, it will be necessary to renounce all assumptions as to the probable duration of a siege. Besides, at the same time that the approaches would become more easy, they would become more simple; thus no cavalier of trenches would be required to drive the garrison from the covered way. In approaching the crest of the glacis the double sap might be dispensed with (*See f*, fig. 1, and *n*, fig. 2), and the boyaux be advanced directly to the salients without danger of being enfiladed, which could not be done if the crest of the glacis furnished a plane of fire. Here the inclination of the glacis, however gentle it might be, would shelter the approach from the fire of any work on the other side of the capital. These approaches thus simplified would be executed on the tenth night, or on the eleventh at latest. If, however, this mode of approach should appear too dangerous, and it should be thought necessary to advance by single sap, the besieger would break out of the third parallel by circular portions (salient *g*, *o*, *p*, fig. 1 and 2) which would be finished on the tenth night; the double sap would be driven to the rounding of the counterscarp on the following night. But even in thus conducting the attack, it is clear that the works would be less impeded by the fire of the garrison in the new fortification than in the old, whose covered way afforded a cross fire on the approaches, and obliged the besieger to advance with the greatest precaution.

It remains now to consider what other defects the suppression of the covered way and the introduction of the glacis *en contrepente* occasion, in addition to neutralizing the advantages of the covered way, and to see if these dispositions are of a nature to facilitate sorties in the degree which Carnot asserts that they will do.

Let us first, suppose, admit that we are considering a strong garrison, as that of Genoa, in 1800, or of Dantzig, in 1813, capable of keeping the besieger at a distance. Under this supposition the immediate disposition of the outworks is immaterial. It is not, in point of fact, on the glacis that the garrison will form their order of battle, nor even will this order be formed within the range of the guns on the ramparts, but rather beyond their reach. The troops will attack in column, and the difficulty the besieged will experience will not be in debouching from the place, but in their march to the besieger, in deploying before him, and in attacking him. The disposition of the ditch, whatever it may be, will have no influence on this operation.

It is not, then, so much for these distant attacks that a fortification ought to be arranged, as for the ordinary defence, being able to extend in the latter case the circle of action, if the extension be desirable, by means of advanced works which ought to be so traced as to allow of being defended by a small garrison.

Under this hypothesis, and when it is no question of meeting the besieger hand to hand, but only of impeding the march of the attack, sorties can in accordance to Vauban's division, be classed under exterior sorties, or those whose object is to close with the guard of the trenches, to spike the cannon of the besieger, and to destroy his works; and into interior sorties, or those whose object is to regain possession of an outwork which has fallen into the hands of the besieger, or to attack the latter when making the passage of the ditch, or executing other work interior to the counterscarp.

Strong exterior sorties, made when the besieger's works are still distant, would certainly be facilitated by the dispositions proposed by Carnot. But since the introduction of parallels this mode of defence has become very perilous; and the same effects cannot be expected from it now as when the approaches were badly traced, and advanced towards the place almost without protection. Then, in point of fact, the garrison were able at any given moment to envelope the heads of the attack, and to destroy both the defenders and their works: sieges were attended with great losses to the besieger, and advanced slowly. The organization of parallels has, however, changed everything;—in connecting the attacks, hitherto isolated, in affording the besieger a strong position opposite the place, and in enabling him always to support the heads of his attack by a considerable force, it has made a complete revolution in the operations of a siege. To pretend to attack the besieger under such circumstances, to encounter troops superior in number, conveniently posted and covered by a parapet, would be extreme rashness on the part of the garrison. Sorties in force cannot, therefore, be recommended but under particular circumstances, and not as an ordinary means of defence. Nevertheless, the necessity for a strong sortie may occasionally arise, and the fortification should be so disposed as to admit of its being executed. But for this purpose it is not necessary to suppress the covered way. It is manifest that its traverses afford cover to the garrison, ready to debouch in an instant on the glacis. A sallyport, or even some steps arranged between the traverses, would allow the besieged to issue out in force, almost with the same facility, and in the same order, as if no covered way existed. It should be remarked, also, that it is almost always from the collateral fronts that the greater part of the troops employed in exterior sorties debouch: in this way they take the besieger in flank, and gain his works without being exposed to his direct fire. But it is not necessary to palisade the covered way of these fronts; and it is easy, therefore, to place as many points for debouch as may be required. What we here maintain is in conformity with the experience of sieges both ancient and modern.

Formerly the covered way or corridor was defended in time of siege by a double row of palisades. It was narrow, and its re-entering place of arms was restricted in size; nevertheless, even when so disposed, not only could sorties be made, but they were frequently attended by important results.

At the present time the covered way is broader; its re-entering places of arms are more spacious, and it is only separated from the country by a single row of palisades. It is evidently, therefore, better adapted for sorties than formerly. Thus in modern sieges, sorties have formed on the glacis with facility, and advanced without impediment; but the besieger, whose attacks are well supported and well connected, rapidly deploys his force; and the sortie, repulsed with loss, is obliged to retire without having obtained any further advantage than the overthrow of a few gabions, which are soon replaced. The difficulty, then, of sorties of this nature does not lie in debouching from the covered way, but in gaining any advantage over the besieger; and it is this difficulty which makes sorties less resorted to than formerly, although their execution has become more easy.

With regard to the retreat of sorties, it can be made easily, and without disorder, by all the barriers, which may be arranged at a few yards interval: the retreat would also be protected by the musketry of the collateral works. Moreover, there would be nothing to fear from the pursuit of the besieger who would suffer great loss should he attempt to press on the sortie. For, under any circumstances, the pursuit must be arrested before it arrives at the palisades and redoubts of the covered way; it would be more than temerity for the sortie to attempt to force the outworks, or even to penetrate into the ditches; this would be to venture into a labyrinth, from which it would be most difficult, indeed, for the besieger to extricate himself.

The difficulties of the pursuit would not, however, be the same with a glacis *en contrepente*: the sorties would pass, it is true, more easily into the ditches, but the advantage of being protected by the musketry fire of the fortress would be lost: no material obstacle would impede the pursuit of the besieger, and if the latter succeeded in mixing with the sortie, or of pressing it closely, he might follow it without great risk to the posterns of the place; always assured of a retreat to his trenches when it became necessary to retire.

It is even more than probable that the besieger will not wait for this opportunity of entering into the ditches, but will steal into them for the purpose of ascertaining the state of the escarps, and of observing the movements of the besieged. He may do so at night whenever it is desirable, even before the establishment of the third parallel.

To conclude then, it is not in relation to sorties in force that the suppression of the covered way is an important advantage; indeed it was not so much to facilitate sorties of this nature that Carnot introduced the glacis *en contrepente*, as to favour weak sorties, who would thus have means of falling on the besieger's work, so soon as they approached within a moderate distance of the place.

But it is precisely with the same object and to secure the same sort of defence, that Vauban improved the covered way; and the experience of sieges, in addition to the suggestions of theory, show that his dispositions are much superior to those of Carnot. The sallyports in the covered way give a passage more than sufficient for the number of men required in a weak sortie; the principal objection is then removed. On the other hand the traverses not only permit the assembling of the men near the points where the sortie ought to *debouche*; but it gives besides, to the defenders, the power of remaining till the last moment close to the works of the besieger, always ready to throw himself on them at any favourable moment; it is a line of counter-approach, ready made and admirably organized; an excellent base for the exterior defence. Before the besieger can gain possession of it, he is obliged to halt, to construct a cavalier of trenches, and to advance with the greatest precautions. Formerly, instances were not rare in which the besieger preferred a subterranean route to surface approaches, unprotected from vertical fire, liable at every moment to have their parapet destroyed by sorties; and which, at length, by their difficulty of execution, and the consequent loss of time, tempted the besieger to crown the covered way by main force, and run the risk of leaving the *élite* of his army on the glacis.

Let this outwork be suppressed, and immediately the defender, in place of finding himself some paces from the besieger, will be 240 to 350 yards from him when he musters in the ditch of the caponniere, or in some similar position; for it cannot be maintained, particularly at night, that sorties in a system with the glacis traced *en contrepente*, could form in the ditches. Under these circumstances, a sortie will not be a mere sally, a momentary apparition of a few men who, rushing on the head of the sap, kill the sappers, overthrow the gabions, and then retire into the covered way; it will rather resemble a distant expedition setting out from points widely divided, and having to retire upon these points after having attacked the besieger. Besides, with a covered way, even when the besieger has crowned the crest of the glacis, each traverse, with its adjacent branch, forms a small palisaded redan where the defence retires foot by foot before the attack, delays it by sorties and other expedients; with a *glacis en contrepente*, on the contrary, as soon as the salients are crowned, the ditches are swept throughout their length; sorties cannot be attempted in force, or even merely to alarm; the places of egress are watched, the distances to pass over are considerable, and under such circumstances small sorties durst never approach the head of the attack: the active defence in place of becoming developed, will become almost impossible.

It is only necessary to throw a glance on the trace of the works to be convinced that the foregoing assertions are not exaggerated beyond their proper proportions. Let us consider, for instance, the attack of the salient of the polygon at the period when it arrives half way between the third parallel and the crest of the glacis, and let us consider the circumstances that would attend a sortie on the head of the approaches. It is evident, in the first place, that the attack would be less sustained by the distant and oblique fire from the body of the place, than it would be were it supported by the fire of the covered way. It is equally clear, that if the sortie be obliged to retreat, the besieger would be able not only to press dangerously on its rear, but would advance parties from the third parallel from the right and left, who would be able to cut off the sortie on the line of retreat to the ditches, which surround the caponniere, which under the conditions assumed are three hundred yards from the head of attack: the sortie will thus find itself cut off in its retreat, pressed in its rear by the troops who have more immediately repelled it, and thrown back on the escarp, without at the same time receiving any support either from the fire of the casemate, or from that of the crenelled wall, unless the fire of these works is directed on both parties, which is an unusual mode of protecting the retreat of a sortie.

None of the casemated works can be considered either as available for the immediate protection of the troops of the garrison, for there would be the danger of the pursuers entering into them at the same time as they; and if the besieger succeeded in establishing himself in these bomb-proof works, the besieged, who cannot see into their interior, would have great difficulty in dislodging him.

Lastly, it must be kept in view that the good effects of weak sorties arises usually, that the works which they destroy are, owing to the close fire from the covered way, reconstructed with great difficulty; but in the case under consideration, the covered way does not exist, and the fire from the place being more elevated, more distant, more oblique, and in less quantity, the damage the sortie might occasion would soon be repaired; and it is for the same reason that the injury which sorties in force occasion in the early attack are of so little consequence.

To the preceding considerations must now be added those which relate to interior sorties. In the ordinary bastion system, when the besieger arrives in the ditch by a subterranean descent, and has no other communication to sustain his works, it is easy to conceive that a garrison determined to sally at any hour of the night, or even of the day, from the extremities of the tenaille, will easily destroy the besieger's works in the ditch, which must be always badly supported, and even to close and render impassable the lower part of the descent and then retreat to a collateral tenaille, or otherwise retrace his steps, without other danger than the fire of a few muskets from the salients of the glacis.

But how does the defence obtain this advantage? Evidently from the existence of the counterscarp which it is now proposed to suppress, since it is clearly the counterscarp which masks the ditch from the lodgments at the salients, and which hinders the guards of the trenches from opposing the weak sortie which may traverse the ditch. Sorties being thus secure from an attack on their flank, have only the musketry fire from the salients, and experience has shown how harmless such a fire is, when delivered in haste.

These advantages would not, however, be obtained with a glacis *en contrepente*, most frequently no descent nor passage of the ditch would be necessary; these operations would be executed by the single sap well protected during its advance. The besieged will not have a greater advantage in opposing them than he will have over any other portion of the approaches of the besieger, and should he attempt to attack them, he will be thrown back in disorder on the escarp of the place.

Thus, then, the dispositions proposed by Carnot, instead of attaining their end, have precisely a contrary effect. They render interior sorties almost impossible; and they greatly increase the danger of sorties against the third parallel, or the approaches of the besieger in advance of this parallel; they would simplify the works of the besieger, deprive the defender of his best musketry fire, and would involve besides many other inconveniences, to which we shall have to recur in following the march of the attack.

There remains now to be considered, before proceeding further, the second element of defence, borrowed from Carnot, viz., those dispositions whose object is to favour the employment of vertical fire.

It has been already remarked, that it was by this fire, combined with sorties, that Carnot proposed to stop the besieger on the glacis. But it is universally known that the projectiles which he proposes to employ would be too small to put a man *hors de combat*: experiments made in England and Germany place this fact beyond all doubt. The balls proposed by Carnot, thrown from a four and a half inch mortar, and falling on a deal plank, produce a scarcely appreciable indentation; they do not penetrate a cloth spread on the ground, but only force it a few inches in the ground. It may, therefore, be concluded that these missiles would only kill a man under the supposition that they fall on his head, but otherwise would only produce a slight contusion. Numerous expedients also might be resorted to for protection against this vertical fire; either the osier bonnets, recommended by Vauban, or the leathern helmets and shoulder pieces proposed by General Rogniat, or what would still be better, small shed-roofs, constructed at intervals with hurdles or fascines, resting at one end on the gabion of the trench, and supported by pickets at the other. This latter expedient has been adopted in very many sieges, more particularly at Dantzig, in 1807: in the latter siege, the garrison made great use of stones and grenades, thrown from mortars, and gave a remarkable proof that the old trace afforded facilities for availing itself of this description of fire, while at the same time it proved how little dangerous it is for the besieger. In the attack which we are considering, the vertical fire would be still less effective, since the attack in place of advancing slowly on the glacis, would approach the place with the rapidity of the flying sap. It is evident, then, that the revolution Carnot asserted would be introduced into the defence by vertical fire, is altogether illusory. It is advisable, no doubt, to multiply vertical fire; but it is absolutely necessary that the missiles projected should be of sufficient calibre to be dangerous, and thus we revert to the old mode of defence, and no new feature has really been introduced into it.

The only advantage that the new dispositions present will be to protect the mortars and pierriers, together with the artillery-men who serve them; but this is no great advantage: usually mortars are placed on those parts of the front of attack which are little exposed to ricochet; under all circumstances they run little risk of being dismounted, and thus it becomes a question whether the money expended in casemates for covering them could not be more advantageously employed.

To conclude: the besieger's works between the third parallel and the crest of the glacis, will have little to fear from musketry fire, at least from a close and continued musketry fire; sorties would be hazardous, nor durst they wait to destroy the works of the besieger without the risk of being surrounded, and of of their retreat being cut off; vertical fire would not be more destructive than usual, so that all the besieger's approaches would be more easily and rapidly executed. To allow then two nights for the completion of the approaches from the third parallel to the glacis, would be to overrate rather than to underrate the besieger's progress. We believe, as we have already stated, that the third parallel might be traced at once through the salients of the glacis; nevertheless we have not availed ourselves of this opinion, but have limited the advance of the attack agreeably to the rules laid down by M. Fourcroy in his attack of a bastion front, in order to render more conclusive the comparison between the ancient and new fortification, and in order not to decide too authoritatively on any doubt which is the subject of discussion.

The eleventh night the crowning of the glacis would be commenced. We shall soon describe how the besieger would proceed with this operation; in the mean time it must be pointed out that the glacis of the whole front will be crowned at once.* For in the new system, with its long fronts and its ravelins so distant, the angles of the polygon, instead of being in re-entering positions, are, on the contrary, placed in advance of the lines formed by the collateral works; and while on this subject it may be further remarked, that if a curve be passed through the angles of the polygon of attack, and if the bastion trace be constructed with the ordinary ravelins, the saillant of the bastion attacked will be found more than fifty-five yards in rear of the line of these ravelins, and consequently cannot be attacked until these latter works have fallen; while in the new fortification, the angle of the polygon will be found more than thirty-two yards in advance. The important advantage of obliging the besieger to execute the near approaches in successive order will be lost, or, at least, very greatly diminished.

With regard to the operation of crowning, it is important to mark the progress; it forms, in fact, the commencement of a new period, in which the fire from

* In the trace shown in the plate, the whole front could be crowned at once. But there seems no reason why ravelins of sufficient saliency should not be added to the polygonal system, as would render it necessary for the besieger to take them before he could crown the glacis of the bastion. In Vol. 2 of the "Papers of the Royal Engineers," Paper VIII. pl. 17, (on the Fortifications of Western Germany,) the trace of a ravelin is given, having a circular masonry redoubt at the gorge, which, if applied to a hexagon, would render its capture necessary before the glacis of the bastion could be crowned. We consider a ravelin, having such a keep, as preferable to the ravelin and its redoubt in the modern system: in the latter system the faces of the redoubt are ricocheted by the same batteries which ricochet the face of the ravelin, and but little room is left on the rampart of the latter for active defence and for resisting the assault on the breach. Where the redoubt is omitted, and a circular keep which is heavily armed, substituted, the terreplein of the ravelin is spacious, and it would be a difficult operation to establish a lodgment on it under fire from the keep.

the loop-holes, and more particularly from the casemates, has to be considered: that fire on which Montalembert founded so many hopes, let us see what there will be to fear from it.

And, firstly, it must be remarked, both in relation to the detached escarp at Coblentz, and to the revetment *en décharge*, at Germersheim, the loop-holes are situated 10 feet above the level of the ditch, and are therefore necessarily below (5 to 8 feet) * the crest of the glacis, which has always an elevation to cover the top of the escarp. The fire from these loop-holes diverted towards this crest must be always considerably elevated, while the glacis falls the contrary way: it is therefore clear that the cavalier of trenches will be concealed from the defenders occupying the *chemin de ronde*, and would be established without the latter seeing a gabion of it. The base of the parapet being thus established, neither the placing of the fascines on the crowning, nor the enlarging of the trench can offer any difficulty. In this operation, then, no other fire can retard the work than that proceeding as usual from the body of the place, except in the present case it would be more distant.

We must repeat the remark, that no traverse, no cover, offers itself in the new trace as cover for a few intrepid men, who concealing themselves within a stone's throw of the besieger, retard the crowning by a close fire of musketry, by fougasses, by grenades, and other such like expedients; the collateral ravelins, 330 yards distant from the salients crowned, could afford an inefficient musketry defence; they have besides too small a saliency beyond the crowning, to require the construction of long and numerous traverses: in a word, in the new dispositions, the fire from the escarp is of no advantage to the besieger, while the suppression of the covered way and the place of arms, deprives him of numerous and important advantages. The operations of the besieger finding themselves thus simplified, and exposed to less dangerous fire, and having besides nothing to fear from sorties, would certainly advance much quicker than formerly.

Let us examine now the effect of the fire of the casemates from the same works, in assuming against our strong conviction that the caponnieres would not be seriously damaged by the fire of the batteries established in front of the second parallel. Let us further admit that the vibration produced by the fire of their guns in the caponniere, already half-mined, would not be sufficient to complete the entire destruction of them; and let us see, even under this supposition, whether the advocates for casemated fire have not exaggerated the value of it.

We shall be able in the first place to apply, up to a certain point, the observations we have made with relation to the loop-hole fire. The caponniere must be covered by the glacis, and must afford a sweeping fire in the ditch; their embrasures must not be made, therefore, high, and consequently the fire directed against the crest of the counter-scarp must be inclined, and would pass over the crest of the parapet of the crowning.† Nevertheless, when the caponniere has two stages of fire, as at Coblentz, the higher battery would see the crowning tolerably well; but then they are 330 yards distant from it, and at this distance the batteries of the place have never prevented the execution of the approaches by night; and we cannot, therefore, admit that they would do so in the present instance.

* It is not supposed that the fire from these loopholes could impede the crowning of the glacis; during that operation of the besieger, the musketry fire of the defenders must evidently proceed from the main work.

† Shells could be lodged from the lower tier of the caponniere, in the parapet of the besiegers' counter-batteries.

The crowning of the covered way would be executed in the usual manner; but it will be necessary afterwards to convert the lodgments into counter and breaching batteries. And it is this operation that the advocates for casemate fire assert will be rendered impossible by the guns which they have kept intact under their bomb-proofs. It is difficult, however, to admit this assertion. In the first place, nothing can be easier than to enlarge and cut away the interior of the battery, and with the *remblai* to increase the thickness of the parapet; afterwards it will only remain to cut out the embrasures. This operation, it must be confessed, will present, as it always does, great difficulty; nevertheless, it is not necessary to exaggerate its amount.

The counter-batteries will be constructed at about 330 yards from the casemated caponniere, the distance at which the batteries in advance of the second parallel are usually constructed from the place. But the mass of the parapet of these batteries is thrown up during the first night of their construction, and the work is continued during the following day. The besieged is quite aware of the position of these batteries; and his artillery, which is unmolested on the ramparts, can divert its fire against them during the first day and second night. But the experience of all sieges shows that it is very difficult, or rather that it is impossible at this distance, and when the mass of the parapet is established, to hinder the completion of the work, or even to retard it. Moreover, the fact should not be lost sight of, that before the invention of ricochet, and even since its introduction, it has happened in numerous sieges that the fire of the flanks has not been subdued at the time when the counter-batteries were established. These batteries were, however, executed and completed under this fire, even when seconded by a cavalier in rear, whose plunging fire would be much more formidable to the besieger than that of the caponniere, which from its low position can see only the crest of the epaulement. We believe, then, that the counter-batteries would be established in the ordinary manner.

If, however, the ordinary mode should appear too dangerous, other means might be resorted to, of easy and rapid execution. Thus, sand-bags might be used for forming the merlons: half the thickness of the parapet might be completed from the interior of the trench, leaving only the exterior part to be finished. A few men would mount the parapet, to whom would be handed sand-bags and gabions for the sides of the embrasures; and in a few minutes the battery would be completed, before probably the garrison had learnt that it had been commenced.

Under any supposition, the operation would be less dangerous than crowning the covered way by main force.

In conclusion: we believe, in consequence of the inferior position of the guns in the caponniere, of their distance from this work, the construction of the counter-batteries would not present greater dangers than are usually encountered in all siege operations, and would be executed in the ordinary manner. If, however, this should not be practicable, other means could easily be devised for establishing them without requiring greater time or risk.

The difficulties we have alluded to only refer to those batteries which are exposed to the fire of the caponniere. Breaching batteries will not be required, if the place is enclosed by a Carnot's wall; even under the supposition that the escarp has not been opened in several places by the fire of the ricochet batteries, it will be only necessary to direct against the salient angle the end guns of the counter-battery, which will soon open a breach of sufficient width.

Should, however, the escarp be constructed *en décharge*, as at Germersheim, regular breaching-batteries (fig. 1, numbers xix. and xx., saillants C and F) will become necessary; but these batteries will have nothing to fear from the artillery in the casemates, since they are not seen by them.

We have entered into considerable detail in the execution of these works, because it is precisely the point on which the superiority of the artillery between the new and old systems depend. If, in fact, it be admitted, as it certainly must be, that the counter-batteries can be established in spite of the fire of the caponniere, it is easy to foretel what the result will be. The experience of ages decides against the casemates; and even De Ville announced, in his time, that their cause was lost. How, in fact, can a parallel be established between firing against a wall where each shot produces numerous splinters and a violent shock, and firing against an earthen parapet, in which the shot buries itself, leaving no trace of its path, and attended by no concussion or vibration. Besides, how great is the difference of danger to which the men who work the guns are exposed, as, also, in the extent of surface to batter. On the one hand a simple mound of earth almost imperceptible; on the other hand an extensive wall, thirty feet high, cut up with embrasures. It must be admitted there must be a great superiority in point of guns in the defence to compensate for such unequal conditions. But here this superiority which Montalembert hoped to establish does not exist. At Germersheim, for example, there are only six guns on each flank; the counter-battery established would be superior in armament. At Coblentz, it is true, Fort Alexander possesses two stages of fire, which allow room for ten guns in each flank; but the guns on the lower stage are of but little use, while the breadth of the ditch, augmented by that of the glacis *en contrepente*, would allow space for the counter-batteries to contain about the same number of guns. It is believed, too, it is useless to assume too great a development of the artillery fire, and that an armament of six guns for each flank would probably be as many as the artillery means of the garrison would allow of. We are convinced that the counter-batteries, in a few hours, would destroy the front wall of the caponnieres, and would oblige the garrison to abandon them; after which, all flank defence would be destroyed, for neither musketry nor artillery fire could be maintained from the ruins of the masonry.

The counter-batteries would also render other services in the event of the fortress being surrounded by a detached escarp. In establishing the flank guns on the prolongation of the *chemin de ronde*, a few rounds from them would demolish the masonry at the salient, after which the fire would sweep the *chemin de ronde*, and destroy the masonry traverses constructed for its protection. These flank guns would also see the flanks of the casemated batteries (p. i., fig. 1, front C D), which are intended to defend the ditch of the caponniere and the terreplein of the ravelin; they would destroy the piers, and cause the greatest disorder in the works themselves.

According to the march of the attack, it would be about the thirteenth day that these batteries would open their fire; the approaches have, in fact, arrived at the salient of the glacis on the eleventh night; on the twelfth the lodgment is prolonged as far as the position of the counter batteries; on the twelfth day the lodgments are widened, the parapets are thickened, and the interior is commenced to be reveted; the work would be finished on the thirteenth night. The crowning of the glacis would be continued and finished the same night.

Thus, then, on the thirteenth night the besieger would be established along the whole crest of the glacis of the front attacked, and would, at the same time, open his fire against the caponnieres and casemated traverses. We have already discussed the result of this struggle; it would be terminated by the close of the day, if the artillery were well served. The same guns would then direct their fire against the redoubts of the re-entering angles, which the glacis *en contrepente* exposes.

The fourteenth day, at daybreak, the place, if it be surrounded with a detached escarp, will find breaches in the latter both at the salients and at the angles of the shoulder; the caponnieres will be destroyed; no flanking fire can be organized; no material obstacles separates the besieger from the body of the place; the *chemin de ronde* will allow the assaulting party to spread itself along the front, and to attack at once along the whole of its development; and the ravelin, also, which defends the enceinte very obliquely, will also be breached at the salients. The assault, therefore, may be given both to the ravelin and to the enceinte at the same time; and thus the siege would be terminated without either a necessity of a descent or a passage of the ditch; operations which are of very great difficulty to the besieger.

Lastly, the assaulting party will not arrive at the escarp by a narrow and subterranean route, nor be obliged to form in the ditch, exposed to fire of every description, without being able either to penetrate into the place or to retreat. In the attack now under consideration the assaulting party would remain in the lodgment on the glacis till the moment of attack arrived, when it would clear the distance between its position and the escarp in a few seconds; no difficulty would be found in re-inforcing the assaulting party; and should a retreat become necessary, it can be in order, and without loss. It is impossible to conceive conditions more favourable for giving the assault, or to find a greater facility for the formation and movements of the attacking party; and these advantages on the side of the besieger are entirely due to the glacis *en contrepente.*

Besides, even before the breaches are made, but as soon as the besieger has enveloped several fronts by his parallels, the garrison will be compelled to the exercise of the greatest precautions to guard the fortress from being carried by assault; the frightful simplicity of the outworks, and the exposed state of the enceinte, would entail on the garrison the labour and fatigue of guarding it most vigilantly from the moment the besieger arrived in the environs of the fortress. At the same time it must be admitted that the difficulty of escalade would be increased by the necessity of descending from the detached escarp, after having mounted its summit.

We have supposed, in the operations which we have described, that the fortress has been surrounded by a detached wall, and that it has not been necessary to establish breaching batteries. It must be remarked, however, that if in place of a detached wall the enceinte is constructed with a retaining revetment, as at Germersheim, the counter-batteries would not alone be able to breach it. But even under this supposition, the extreme or flank guns of the batteries will be able to open and break down the escarp in directing its fire, first against the detached wall which closes the court at the salient, and afterwards against the loop-holed wall, which has been constructed at great expense in rear of the mortar casemates, which would render these casemates altogether untenable; the communications with the adjoining escarp gallery would also be destroyed, and the besieger would, it is conceived, be able to establish himself in the ruins of the casemates, close to the postern which leads into the interior of the place. No doubt this postern might be impassable from its ruined condition, or it might be barricaded by the besieged; but the besieger has only to explode in the ruined casemates an overcharged mine, in order to open a route by means of which the assault might at once be given.

Should it, however, be necessary to form breaching batteries, there would be no difficulty in their construction. Commenced twenty-four hours after the counter-batteries, they would open their fire on the fourteenth day, and this day would prove the last of the defence, for then the body of the place would be breached, and the main ditch would remain without flank defence.

Such, we conceive, would be the march of the attack against the new fortification; we have supposed it as slow as it could be estimated at, in order not to magnify the defects of a system which, in our opinion, is radically vicious. We feel convinced that, in giving proper weight to the obstacle that the musketry fire and other means would oppose to an ordinary attack, and which musketry fire in the new system is wanting, we have rather underrated than overrated its progress. A few observations will now be made which could not well be introduced before.

We shall remark, in the first place, that the body of the place in the new system presents much less simplicity than in the old. Instead of unbroken terrepleins and parapets, everywhere accessible to the garrison, caponnieres are substituted, which can only be arrived at by posterns, far removed from each other; the defenders of the caponnieres are isolated, concealed, and dispersed in groups along the whole contour of the fortress; as a consequence, they must be badly looked after, and themselves feel that sense of weakness which is the necessary accompaniment of isolation. At the moment of danger, the commander, in place of being able, by a rapid movement along the rampart, to ascertain the state of the body of the place, and that each man is at his post, must penetrate into the casemates at a great expense of time, an element of so much importance in considerations of this nature. In a system traced like Fort Alexander, it would be necessary, in order to make this inspection, to throw open the posterns of the enceinte and the doors of the caponnieres, an operation which in the presence of an enemy would be attended with the greatest inconvenience. We have seen, besides, that this communication is seen and counter-battered by the besieger as soon as he has crowned the salients of the glacis.

It is the same almost in the system adopted at Germersheim: the gates placed in the walls which connect the caponnieres with the body of the place would be destroyed by the first fire of the battery; the safety of these works, on which depends the flanking of the escarp, is thus at once endangered.

Lastly, it would be necessary that each of these caponnieres should be manned by some troops, in addition to the artillery, which necessity would cause the garrison to be greatly divided. These troops would be entirely passive, for the caponnieres are not constructed for musketry defence, which is a great defect. It was indeed with good reason that the ancient engineers never lost sight of fire-arms as a defensive weapon in the disposition of their trace; they so arranged it that, wherever a soldier was placed, he should be able to do good service with his musket, and this maxim derives importance from the consideration that, towards the end of a siege, the artillery of the place is probably silenced or its ammunition expended.

In order to secure the fortress against assault, it would be necessary to keep a part of the embrasures of the caponniere open, and as the arrangement must be adopted along the whole circuit of the fortress, such openings would be very objectionable, however carefully they might be watched.

Another defect arises from the mode in which the opening formed by the ditch of the ravelin is closed. The traverses by which these openings are masked, are indeed sufficiently massive to afford cover even under the supposition that their piers are cut away, and that the arches consequently fall in. But the wall between the piers (*murs de masque*) are easy to destroy, after which the besieger would be able to breach the body of the place through the openings between the piers, which would be a great advantage, as we shall see hereafter. When also the besieged is obliged to abandon these traverses, they give rise to considerable dead spaces in the ditch of the ravelin; altogether the arrangement seems inferior to that adopted at the school of Metz, which possesses the same advantages without the attendant defects.

### Attack against an Enceinte Provided with an Interior Retrenchment.

The preceding considerations, based on an examination of the new system in its simplest form, are more than sufficient to show the true value of that system; nevertheless it may not be without interest to push the inquiry a little further, and to examine the means employed in some fortresses to augment the resistance of the ordinary trace. The examination will tend to bring out more prominently the defects already indicated, and will also disclose others which have not yet been alluded to.

We shall consider, first of all, an enceinte, with an interior retrenchment similar to that sketched in the reconnaissances of Germersheim and Ingoldstadt. (See the dotted lines, fig. 1, salients B & C.) These retrenchments are formed of large barracks established in rear of the angles of the polygon, and connected with the enceinte on either side by coupures, which fall beyond the redoubts at the re-entering angles. It will be admitted that these redoubts, as well as the traverses, which close the ditch of the ravelin, are too massive to be demolished by the besieger's batteries, so as to admit of the escarp of the enceinte being seen above their ruins.

The besieger then finding it impracticable to breach the body of the place in rear of the retrenchments, will be obliged to attack the latter directly; under these circumstances, if the enceinte be composed of a detached escarp, the assault may at once be made by the breaches at the salient, both on the outworks and the body of the place, the assaulting party spreading themselves along the *chemin de ronde*, and making the attack with an extended front. If, on the contrary, the revetment be a retaining one, as at Germersheim, it will be necessary to establish breaching batteries against it (fig. 1, No. 19 & 20), which, commenced on the twelfth or thirteenth night, would open their fire on the morning of the thirteenth or fourteenth.

On the evening of the same day, or the next day at latest, the breach will be practicable, and the assault will be given at the same time, both on the ravelin and enceinte. In a system well traced, the interior retrenchment would make it necessary for the besieger to establish himself with some precaution on the breaches of the ravelin and enceinte, to sap along their terreplein, and to maintain a safe communication with the works in rear. In the new fortifications these precautions are no longer necessary. At the same time that the assault is given to the enceinte and ravelin, a detachment would be directed against the central caponniere, which passing close to the foot of the escarp would be unseen from its loop-holes, and arrive at the caponniere without being exposed to a single shot. An attempt would then be made to blow open the gate of the postern in the curtain; should it succeed, the retrenchment will be turned, and must fall; but should the attempt not succeed, the assaulting party would lodge themselves in the casemates of the caponniere, cutting off all communication with the outworks, and threatening an attack on the ravelin by the gorge, at the same time that this work is assaulted by a superior force in front. The defenders finding themselves between two fires, with their retreat cut off, would not make a serious resistance; they would be obliged to abandon the work without the least hope of regaining it, for the occupation of the caponniere by the besieger would paralyse all offensive operations.

The lodgment on the body of the place would be made with equal facility. The assaulting party would not be exposed to any flank fire. If the breach were firmly defended, its attack would be an operation of the usual nature, in which the besieger being the stronger party would prevail; or if the besieged rather resorts to his mines and to artificial obstacles for its defence, then small assaulting parties must be employed in the manner laid down by Vauban. In either case the assaulting party, after driving the defenders back, would spread along the *chemin de ronde*, and berm, and would be able also to establish a lodgment along the whole line of the exterior crest, carrying on the work both by day and night, for the exterior slope of the parapet is unseen from any part of the trace; and this advantage to the besieger arises from the vicious disposition of the system causing the flanking works to fall before the works they are intended to flank, and the same cause renders the besieger complete master of the ditches.

When the lodgment at the exterior crest is extended along the whole front, it will form a sort of parallel at the salient of the polygon; the besieger will have the means of constructing as powerful batteries as he pleases, as also, of selecting those sites, which appear most favourable for breaching the casemated barracks which form the retrenchment. Perhaps, however, he may be induced, from being so completely in possession of the ditch, to open the enceinte by a mine at a point in rear of the coupure of the retrenchment, which being thus turned would dispense with the construction of breaching batteries. In a word, the besieger, in undisturbed possession of the ditches, will have "l'embarras du choix" among the numerous means of attack, each of which can be executed almost without danger and difficulty and at a small expenditure of time.

### Attack of an Enceinte Protected by Counterguards.

We have hitherto supposed that the body of the place has been strengthened by a simple interior retrenchment. Let us now assume that it is surrounded by a counterguard similar to the front of Fort Alexander, at Coblentz (see fig. 2), and let us endeavour to ascertain the value of this new combination.

It is, first of all, evident, that the attack will be directed against the exterior line in the manner we have already described. We shall not, therefore, enter into details further than to point out the principal differences between the operations of the attack already given, and those which we are about to consider.

The most important of these differences arise from the circumstance that, the body of the place, and the work by which it is surrounded, give to each other a mutual support which secures them from the danger of being insulted. The first batteries would still be able to ruin the caponniere and to breach the detached escarps; the glacis *en contrepente* would also permit the besieger to reconnoitre the state of the breaches, to assault the counterguards and the caponniere, and perhaps to destroy their armament; but it cannot be admitted that permanent possession could be taken of these works, defended as they are by the body of the place; still less that the body of the place could be carried, except by regular approaches. The exterior enceinte will have the effect then of obliging the besieger to the delays attendant on a regular attack; an important advantage which should make counterguards to be considered as a necessary addition wherever the glacis *en contrepente* is adopted.

The attack would be conducted in the ordinary manner till it arrives at the crest of the covered-way; there it would meet with a small masonry redoubt, which did not exist in the system previously attacked. The object of this redoubt seems to be to take the ditch in reverse, to impede the crowning of the glacis, and perhaps to serve as a *point d'appui* for a system of countermines.

It must be remarked, however, that these small redoubts, which are almost buried in the counterscarp, are open to a variety of attacks. In the first place, in consequence of their exterior wall not being flanked, it would be practicable to sink a few small shafts, in which powder bags might be placed, for the purpose of blowing up their piers; or means might be found to introduce smoke composition into the loopholes, with a view of poisoning the air, and rendering them untenable; or the loopholes might be masked by filling up the ditch with fascines, so that it does not appear likely that the addition of these redoubts would impede the progress of the attack.

The redoubts, too, but feebly support the retreat of the troops. When a sortie enters the ditch, it is clear the fire of the casemates must be suspended, should the besieger enter it with the sortie. We have already seen, that while a glacis *en contrepente* facilitates the egress of the troops, it renders their retreat more perilous. Still, however, when the body of the place is not surrounded by exterior works, the sortie can take refuge in the ditch of the great caponniere, and in this way gain the neighbouring front. But in the system against which the attack is now directed (pl. 1, figs. 1 and 2), the sortie, in place of having this retreat open to them, is obliged to retire through the narrow openings left at the extremity of each counter-guard, so that if badly pressed it would enter into the interior ditch with more difficulty than in a covered-way furnished with barriers. The besieger, also, while in the third parallel, would be nearer to these passages than the besieged, supposing the sortie to be engaged with the approaches on the capital; it would therefore be easy for the besieger to cut off the retreat of the sortie, and as he would enter into the ditch at the same time as the latter, the casemated fire, if indeed any were left, would be paralysed. It is considered, indeed, that the fire from the detached escarp would contribute to check the pursuit of the besieger; but this fire, too low to discover the country, and too high to defend the ditch, would be ineffective, and, as has been previously pointed out, far inferior to that of the covered-way, in resisting any sorties from the besieger's trenches. Lastly, the besieged would be shut up in his works without a possibility of sallying from them, as soon as the glacis is crowned, when the besieger would see and command the passages by which alone egress can be made. This vicious disposition of the communications, added to the suppression of the covered way, which forms the true base of all the exterior operations of the besieged, will entirely neutralise that active defence for which ostensibly the new dispositions are intended to promote. On examining these new dispositions, it is found, in point of fact, that they substitute, for all the openings which may be made from the covered-way on the glacis, only two communications, which, if not seen from the besieger's trenches, are at least entirely accessible to him, and are but feebly defended. This result is but a poor compensation for the disadvantages attending the suppression of the covered-way and revetted counterscarp.

From these considerations it appears that the approaches up to the crest of the glacis in our present attack would advance quite as rapidly as an attack directed against an ordinary enceinte, since the fire from the place is less dangerous for the besieger, and the execution of sorties more difficult. The same remark will apply to the crowning of the glacis, as well as the batteries constructed in the crowning. Those which are established on each of the salients attacked (Nos. 14, 15, 16, 17, 20, 21) are intended to complete the destruction of the casemates, to ruin the small redoubts placed at the roundings of the counterscarp, and to breach the extremities of the ravelin and counterguard.

It is believed that the batteries will be able to execute these several objects at the same time; because the destruction of the casemates, as well as of the adjacent escarps, if not already effected by the ricochet fire, will only require a few additional rounds from these batteries. Adjoining them others might be constructed, composed of mortars and howitzers, to annoy the defenders on the terreplein of the works, and to ricochet the long branches of the counterguards.

In the re-entering angle, formed by the ravelin and counterguard, other batteries (Nos. 18 and 19) might be established, if considered necessary, for the purpose of enlarging the breaches already made at the extremities of these works, by the batteries at the roundings of the counterscarp. If the fortress be surrounded by a detached wall they will not be required.

Batteries (Nos. 18 and 19) will be finished on the thirteenth night, and will open their fire on the following day. Those at the salient will have commenced firing twenty-four hours earlier; this will be sufficient time to put all the defences opposed to them in a complete state of disorganisation.

On the fourteenth day preparations would be made for effecting a lodgment on the exterior works, and at dusk this operation would be executed in the manner already explained. The attacks on the ravelin and the counterguard made simultaneously at the salient and at the extremity could not mutually support each other: the reserve would be posted in the ditch in the dead space caused by the ruined casemated traverse; as soon as the defenders were driven from the ravelin the besieger would establish himself on the exterior slope of the counterguard, forming the lodgment near the top of the slope, and throwing the earth on the superior slope, and thus turning the parapet against the place.

The exterior slope of the ravelin being seen from the body of the place, the same mode of proceeding could not be adopted as in the counterguard, and it would be necessary to make an opening in the parapet to communicate with the interior of the work. For this purpose advantage would be taken of the end wall of the casemated battery which flanks the ditch of the counterguard, by which means the summit of the breach would easily be gained; and in order to arrive at the gorge it would only be necessary to cross the terreplein of the work. This operation would simply amount to executing a trench about sixteen yards long which, commenced from both ends, might be done by the single or flying sap, and would be completed during the night.

While lodgments were being established on the outworks, the approaches for arriving at the foot of the breaches would also be commenced. In establishing these communications from the re-entering angle formed by the ravelin and counterguard, and in the undefended space formed by the massive of the traverse, they will be completely protected, without any special operation being required for the passage of the ditch. The lower part of the descent into the ditch will be also protected; but the upper part being seen from the body of the place it would be necessary to form it by single sap for a distance of twenty yards.

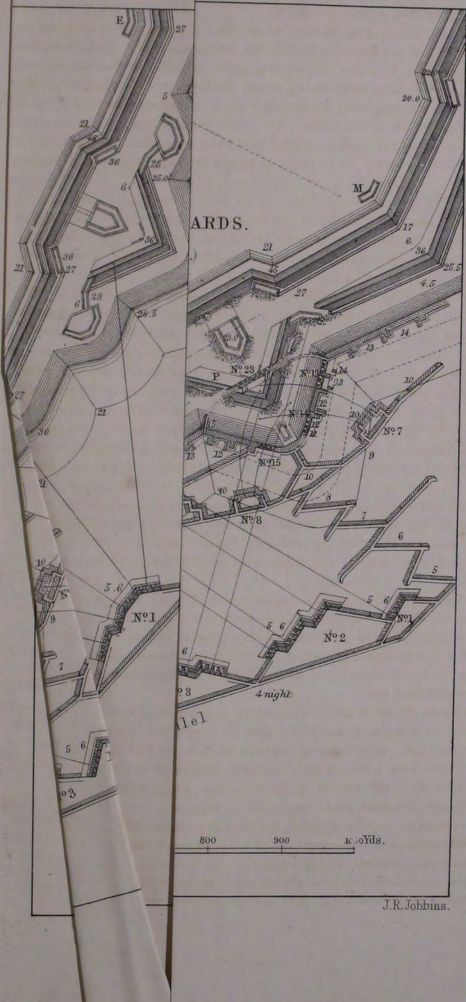
At the end of the fifteenth night, the besieger would be lodged on the exterior works, and would besides have established his stores and reserves in the spacious ditches of the counterguards, which are entirely unseen from the body of the place. The next day the lodgments would be improved, and enlarged at those points intended to be converted into batteries.

There is every ground for believing that the flanking caponniere at this period would be half ruined by the fire of the batteries in the second parallel. The crest of the counterguard is situated at about 300 yards from the caponniere, and not being more elevated than the glacis in the preceding attack the results ought to be the same. It is conceived, in consequence, that these caponnieres will be entirely disorganised, and that it will not be required to establish special batteries against them; should the result, however, prove otherwise there would be no difficulty in constructing these batteries. It would be only necessary to enlarge the lodgment at the salient of each counterguard, and sufficient space would be obtained for placing the required number of guns in battery. In the present case the armament has been limited to seven guns for each face; this number appears sufficient to complete the destruction of the caponniere, and to open breaches at the salients of the polygon; but it should be remarked, that the available space is sufficient for ten guns being placed in position, so that the defence, instead of having the superiority of artillery, will be inferior in armament.

On the terreplein of the ravelins batteries No. 23, 25 will be established, which opening the body of the place to the right and left of the caponniere, as well as in the centre, will turn the interior retrenchments, unless, indeed, it consists of a third enceinte established in rear of the two first. All these batteries would be commenced on the fourteenth or fifteenth night, and the breaches would be opened by the sixteenth day.

Another mode of attack would be to open the counterguard by a mine, through which the guns on the glacis would be able to breach the body of the place. The counterguard not being flanked, it would be easy for the miner to destroy any portion of it. This circumstance, however, facilitates the establishment of batteries on the work itself; and it is for this reason that the latter mode has been preferred as being more secure and easier to execute.

But whichever mode may be adopted, the besieger would, during its execution, open the communications or passages at the extremities of the counterguards, as also those below the traverses which close the ditch of the ravelin; he would throw down the small wall which sometimes exists at the extremity of the ditch of the ravelin, and would then enter into the main ditch without the laborious




J.R.Jobbins.

operation of a descent. No difficulty will be experienced in making the passage of the ditch, for the destruction of the caponniere will have left it without flank defence; and the only fire to which the sap will be exposed will be from the loop-holes of the escarp, opposite to the point where it enters into the main ditch, which the besieger may mask by placing boards against them, or otherwise by throwing into the casemates, through the loop-holes, smoke-composition to render them untenable. If the front had a detached escarp, it has already been shown that the chemin de ronde would not be tenable.

It is possible also that at this period the escarps on the right of the ditches of the ravelin would be breached. It has been already shown that the besieger is able, after destroying the walls between the piers of the traverses which close the ditches of the ravelins, to fire through the casemates from his counter batteries 14, 15, 20, 21. In this way the enceinte may be breached without establishing breaching batteries on the exterior works.

The mode of attack last indicated would be an advantageous one for the besieger, if the gorge of the counterguard were furnished with a counterscarp gallery to oppose by mines the establishment of a lodgment on the work itself. By attacking at once the body of the place, the danger and delay of the construction of the counter batteries on a countermined counterguard would be avoided.

At the same time the difficulty of attacking and paralysing such a system of countermines need not be over-rated: in the event of the garrison foreseeing that the casemates in the ditch of the ravelin must become untenable, should take means to destroy them, and thus render it necessary for the besieger to establish a lodgment on the counterguard, for the purposes of breaching the enceinte. The time necessary for silencing the defensive mines of the counterguard would be very limited. Without entering into the detail of the attack, it will only be stated that a system of countermines, in which the principal feature is a gallery which presents a long side to the besieger's mines, cannot be considered as a formidable obstacle. We are convinced from the result of experiments, that by the proper employment of globes of compression, two or three days would be the term of such a war of mines. The besieger would then be enabled to make the assault on the breaches in the body of the place on the nineteenth or twentieth day: a result quickly obtained, considering that the besieger during his attack has carried two enceintes, strengthened by a small system of countermines.

The preceding observations are sufficient to show that the means taken for strengthening the enceinte partake of the general defects of the polygonal system. The exterior defence becomes neutralised by a glacis en contrepente, combined with the limited communications through which sorties can issue and return; the works affording flanking fire are among the first to be destroyed; and lastly the enceinte, being deprived of the bastion trace, leaves the besieger, after the destruction of the caponniere, master of the ground, and relieves him from the delay and danger to which the besiegers' work in a regular attack ought to be exposed.

In conclusion the translator has only to repeat his remark, that the fronts chosen by M. Mangin for his attacks do not fairly represent the Polygonal system employed in Germany: in the next volume of the Professional Papers this system will be more particularly referred to.

J. WILLIAMS,
Captain Royal Engineers.

# PAPER XIV.

## BERMUDA.

## Remarks Explanatory of the Gale that occurred in the Atlantic between the 22nd of September and the 3rd of October 1852, to accompany the Meteorological Record for the Month of September at Bermuda. By Lieut.-Colonel Alexander, Royal Engineers.

The accompanying sketch and record (to accompany the column of remarks of this month's return) show the geographical positions of certain vessels during the recent storm which raged in the Atlantic from the 22nd of September to the 3rd of October, 1852, laid down from the several logs, and information obtained at Bermuda either from the several commanders or from the public papers. The greater number of these vessels put into these islands for repairs, after sustaining severe damage, and the logs and information recorded were most readily given on board the vessels separately soon after their arrival. From the data afforded from the information so procured, the probable track of the cyclone has been projected in order to see how far the rotatory theory is borne out in this instance by the direction and force of the wind, and state of the weather as experienced by each vessel in its daily recorded position. It is unfortunate that in some instances these vessels were unprovided with barometers, and in others they were without the advantages of chronometers; so that it has not been possible to furnish information as to the rise and fall of the barometer, or to trace with perfect accuracy the precise daily position occupied by each vessel. Sufficient information has, however, been procured as to establish clearly that the late severe storm was a revolving gale, slowly and gradually progressing in the direction shown by the dotted line in the sketch. That the wind in all instances veered in the direction laid down in the rotatory theory for cyclones in the northern hemisphere. Circles of different colours have been projected on the sketch, described from the assumed centres of the vortex, on each recorded day, and small arrows of the same distinguishing colours explain the direction of the wind experienced by each vessel, as taken from the several logs on the corresponding days. A mere inspection of the sketch will serve to show how in most instances the wind has veered in conformity to the theory of the law of storms.

The instances of the brigantine "Quadruple," and the brig "J. A. Jesurun," are both remarkably curious as to the correctness of this theory; also that of the Halifax steamer "Levantine," in comparison with the direction and force of the wind at Bermuda; the steamer being behind the gale, made her passage with a fair but violent wind commencing at N.N.E., and veering to N.E.N. and W.N.W. At Bermuda the gale commenced on the night of the 29th; during the previous twenty-four hours there prevailed a constant roaring of the sea on the southern shore, with very threatening appearance, and much lightning extending from S. to W.N.W. The lowest record of the barometer on the 30th of September was 29·619, with the wind S.S.W., whereas the brigantine "Eolian," distant about 200 miles to the westward of these islands, apparently in the vortex, had the barometer as low as 27·5, with the wind most violent from S.E., but shifting in all directions, blowing a hurricane.

CHARLES C. ALEXANDER,
Lieut.-Col. Royal Engineers.

*Nov.* 5, 1852.

---

RECORD.

Extracts from the logs of certain vessels exposed to the gale that occurred between the 22nd of September and the 3rd of October, 1852, and minutes of information touching that event, to accompany the Meteorological Record for the month of September, 1852, at Bermuda.

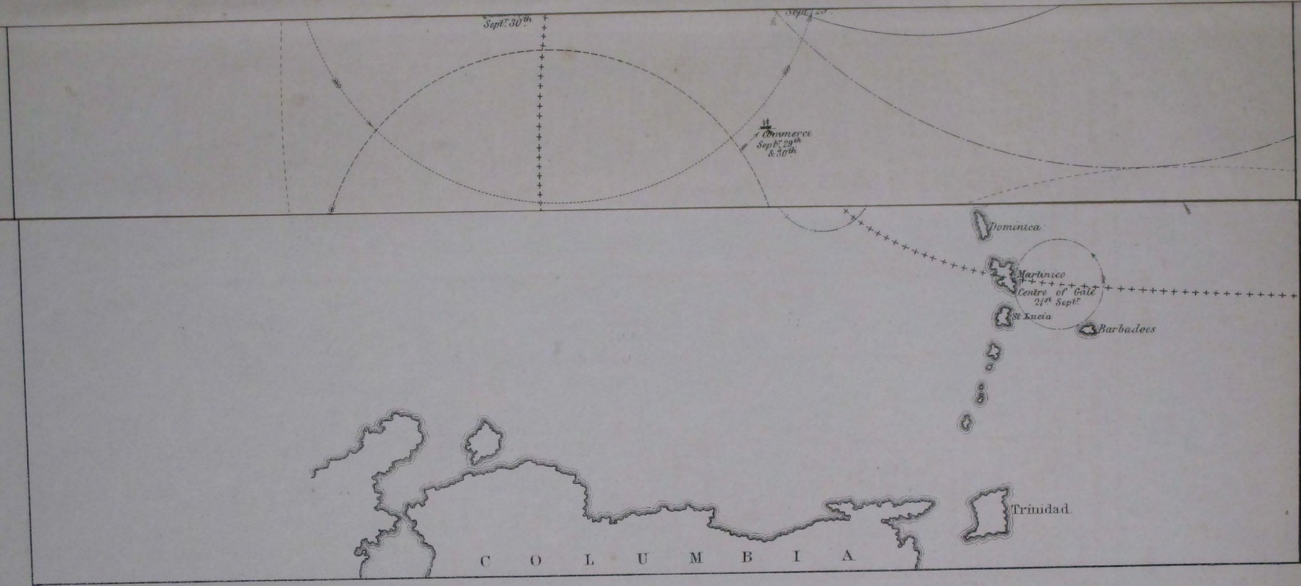
| Name of Vessel. | Latitude. | Longitude. | Date. | Remarks. |
|---|---|---|---|---|
| 1. Brigantine "Devonshire," from Newfoundland to Grenada. | 16° 40′ 0″ | 58° 30′ 0″ | Sept. 22 | The gale commenced at about 8 P.M., on the 21st of September, in a squall from N.N.E. At 2 A.M. 22nd, hauled gradually round to S.E. The ship was thrown on her beam ends three times; cut away foretop-mast; lost boat and part of deck-load. |
| 2. "Standard." | 16° 30′ 0″ | 59° 40′ 0″ | | Encountered a hurricane of eighteen hours' duration; sprung bowsprit, lost sails, &c. |
| 3. Island of * | | | Sept. 22 | *From the Bermuda Gazette.*—This island suffered most severely, many houses, trees, &c., being destroyed. |
| 4. Island of Antigua. | | | Sept. 22 | The gale commenced on the 22nd of September, at about 11 A.M., from N.E. and E.N.E.; was at its height at about 5¼ P.M., when the barometer had fallen to 29·580; from 6 to 6½ P.M. the centre seems to have been passing, the wind gradually veering to E. and E.S.E., and ending at 5 A.M. on the 23rd, wind S.E. |

* Name of island not inserted in original MS.; it seems to be one of the West Indies.

| Name of Vessel. | Latitude. | Longitude. | Date. | Remarks. |
|---|---|---|---|---|
| 5. Brigantine "Lady Chapman," from Barbadoes to Baltimore. | 20° 0′ 0″ | 65° 15′ 0″ | Sept. 26 | On the 24th of September left St. Eustatius, West Indies. On the 25th weather fine, moderate breeze; at 10 P.M. the same day the wind increased to a gale in a squall from E.S.E.; and on the 26th instant, at 3 A.M. was obliged to heave-to, the wind continuing to blow from E.S.E. with such violence, that it was impossible to look to windward, the water being blown with such force over the vessel; at the same time we could not see to leeward more than the length of the ship, and the vessel gradually being pressed under water at the time, concluded to cut the rigging so as to allow the fore-mast to go overboard, which it did, breaking in two places. The storm was the severest ever experienced by any one on board; the noise of the wind was more like thunder than anything else. During the hurricane the wind blew from every quarter of the compass and moderated at S. |
| 6. Brigantine "R. W. Packer." | 28° 30′ 0″ | 67° 10′ 0″ | Sept. 29 | On the 28th of September the gale commenced, wind from the E.; it gradually increased to a perfect hurricane on the 29th, wind still E. At noon this day it veered towards the S. Lost topmasts and part of deck-load. Wind S.E. A sailor was blown out of the fore-rigging and broke his leg. In the evening the gale was at its height, blowing furiously from the S., gradually moderating next day and veering to S.W. and W. |
| 7. Brig "Commerce." | 30° 30′ 0″ | 65° 0′ 0″ | Sept. 30 | Reported to brig "Triumph" that the gale commenced with her on the 29th from the S.E., and was at its height from the S.W. on the 30th. |
| 8. Island of Bermudas. | 32° 22′ 57″ | 64° 40′ 0″ | | September 28th. Very close and oppressive all day; wind light, with occasional puffs from the S.E. and S.S.W.; great |

| Name of Vessel. | Latitude. | Longitude. | Date. | Remarks. |
|---|---|---|---|---|
| 8. Island of Bermudas (*continued*). | 32° 22′ 57″ | 64° 40′ 0″ | | roaring of the sea on the S. side; sky overcast, with occasional light winds, rain and mist; almost constant lightning from the southward and westward in the evening, accompanied with distant thunder and heavy clouds to the W. and N.W. September 29th and 30th, the wind blew with great violence both days, and until noon on the 1st of October, when it began to moderate, and on the 2nd died away. The wind veered in these four days from S.S.E. to S., S.W., and N.W.—*Extract from Meteorological Registers for September and October.* |
| 9. Schooner "Adeona," from New Orleans to Bermuda. | 32° 38′ 0″ | 67° 43′ 0″ | Sept. 30 | The gale commenced on the 29th, wind eastward at P.M.; main stay-sail blew away, Sept. 30th; stiff gale, all hands up to shorten sail; wind E.S.E. at 8 A.M., blew a hurricane; put out a dreg expecting every moment to have to cut away fore-mast; ship leaking and labouring very much. The wind, however, gradually decreased in violence in the evening, the wind going round to W.S.W., and leaving off on the 1st of October at about N.W.; made Bermuda on the morning of the 3rd. |
| 10. Schooner "Medora." | 32° 50′ 0″ | 65° 20′ 0″ | Sept. 30 | The gale commenced on the 29th, wind light, but increasing from E.S.E.; the next day it veered gradually to S. and S.S.W., and finally moderated at N.N.W.; lay-to for three days; lost some sails, &c. |
| 11. Brigantine "Quadruple." | 33° 1′ 0″ | 70° 6′ 0″ | Sept. 29 | Moderate breeze on the 29th from E.N.E., and at 8 P.M. a heavy gale from N.E.; hove-to under main stay-sail; a heavy sea from S.E. The gale continued the next day, viz. the 30th, the wind backing to the N.W., from which quarter it blew very heavily and gradually moderated. |
| | 32° 17′ 0″ | 69° 30′ 0″ | Sept. 30 | |

| Name of Vessel. | Latitude. | Longitude. | Date. | Remarks. |
|---|---|---|---|---|
| 12. Brigantine "Eolian," from New York to St. Juan de Nicaragua. | *33° 30′ 0″ | 68 °20′ 0″ | Sept. 29 | The gale commenced at 6 P.M. on the 29th from the eastward. At 10 P.M. main stay-sail blew away. 11 P.M., stiff gale, wind increasing and veering towards the S. 12 midnight, lost all sail, blowing a hurricane from S.E. At noon on the 30th cut away masts, wind in same quarter, barometer 29·5, the wind gradually veering with unabated violence to the S.S.W. and subsiding the next day, finally leaving off at N.W. * This was at 6 P.M. on the 29th. |
| 13. Brig "Triumph," from Demerara to Liverpool, N. Scotia. | 33° 51′ 0″ | 64° 37′ 0″ | Sept. 30 | The "Triumph" had wind variable from S.E. and E. S. E., course N. b. W. 12 miles S. of Bermuda lighthouse at midnight; very squally, and threatening wind from S.S.E.; course N.E. to N.W., averaging 6½ knots. On the 30th of September, at noon, very strong gales from S.S.E. and sea from S. wind increasing. October 1st, at 1 A.M., hove-to on starboard tack; at 4 A.M. terrific gale from N.E.; wore ship at 10 A.M.; shipped heavy sea and thrown on beam ends; cut away masts; the wind veered gradually to E.N.E., and on the 2nd of October moderated and died away, wind at N.; bore up from Bermuda. |
| | 35° 51′ 0″ | 66° 0′ 0″ | Oct. 1 | |
| 14. Brigantine "Princess Royal," from New York to Bermuda. | 34° 27′ 0″ | 67° 6′ 0″ | Sept. 29 | On the 29th of September, wind light from S.E. variable at midnight, increasing in violence from same quarter; the next day the wind veered gradually towards the S. and blew with great violence at noon; hove-to on the port tack, wind S. (blowing a hurricane); at 4 P.M. wore ship and came-to on starboard tack, wind veering towards the westward, and at noon on the 1st of October moderated and veered to W.N.W. |
| | 33° 10′ 0″ | 66° 36′ 0″ | Sept. 30 | |


Septr. 30th.
Commerce
Septr. 29th
& 30th.
Dominica
Martinico
Centre of Gale
21st Septr.
St. Lucia
Barbadoes
Trinidad
C O L U M B I A

| Name of Vessel. | Latitude. | Longitude. | Date. | Remarks. |
|---|---|---|---|---|
| 15. Brig "J. A. Jesurun," from Boston to Curaçoa. | 38° 20′ 0″<br>38° 30′ 0″ | 68° 40′ 0″<br>68° 30′ 0″ | Sept. 30<br>Oct. 1 | On the 30th of September moderate breeze from E. and E.N.E., wind gradually increasing at 4 P.M.; hove-to on starboard tack, blowing very hard, confused sea. The next day (October 1) it blew a severe gale from N.E., moderating at about 3 P.M., and wind veering to N.N.E. |
| 16. "Lady Sale," from St. Andrew's, N.B. | 40° 20′ 0″ | 64° 4′ 0″ | Oct. 1 | The gale commenced at E.N.E. on the 1st of October, and gradually hauled to N.E. on the 2nd, the gale still blowing with great violence, veered to N.N.E., and gradually moderated; it blew for thirty hours with great violence; lost deck-load, and arrived at Bermuda on the 6th of October. |
| 17. Steamer "Levantine," from Halifax, N. Scotia, to Bermuda. | 42° 26′ 0″<br>38° 58′ 0″<br>35° 0′ 0″ | 64° 0′ 0″<br>64° 30′ 0″<br>66° 30′ 0″ | Sept. 30<br>Oct. 1<br>Oct. 2 | Left Halifax on the evening of the 29th of September, light wind from N.N.E., moderate breeze, September 30, from N.N.E.; barometer 30·20. October 1, wind fresh from N.E. and increased in the afternoon to a strong gale, and blew a terrific gale from that quarter during the night; barometer 29·6. The next day (Oct. 2), wind moderated and veered to N. with a rising barometer 29·8. |

True Extracts.

CHARLES C. ALEXANDER,
Lieut.-Col. Royal Engineers.

# PAPER XV.

## METEOROLOGICAL OBSERVATIONS.

The Inspector-General of Fortifications having directed that abstracts of the meteorological observations taken at the foreign stations should be made and published annually in the Corps Papers, I have prepared the forms of abstracts, and have filled them in as far as the registers which have been received from the stations have enabled me to do so; but I regret to say that, in consequence of the great delay which has taken place in transmitting the instruments from the Tower, no registers have been received as yet from several of the stations, and only one, two, or three, depending upon the time which has elapsed since the instruments were received, from others.

It is therefore obvious that, as yet, we are not in a position to give the abstracts, though we trust to have a perfect set ready for the next volume. The self-registering maximum thermometers, which were forwarded to the stations, were known to be of a defective construction, and liable to get out of order from the entanglement of the indexes in the mercury, and a more perfect form of instrument has long been felt to be a great desideratum amongst scientific men, and this want has fortunately been supplied by the thermometer recently invented and patented by Messrs. Negretti & Zambra; in these instruments there is no moveable index; the mercury in ascending is forced past a partial obstruction in the tube, which is sufficient to break the thread of mercury when the temperature decreases, and the mercury in the bulb contracts; the broken thread of mercury thus remains at the highest point it has reached. After the maximum temperature has been registered, the thread of mercury is again united by merely raising the end furthest from the bulb and gently tapping it. The Inspector-General has recommended that three of these thermometers shall be sent to each of the stations, and as these are the only instruments which have any known imperfection, it is hoped the sets at the different stations will soon be made quite perfect.

HENRY JAMES,
Capt. Royal Engineers.

AIDE-MÉMOIRE TO THE MILITARY SCIENCES.

## NOTICE.

THE Second Edition of the first volume is just published, and may be had by application to Mr. WEALE, Publisher, 59, High Holborn, London; price One Guinea, bound in green cloth, to correspond with the Professional Volumes, 8vo. edition.

The whole work, in three volumes, may be obtained from the same source, bound in green cloth, price 4*l.* 10*s.*

The Officers of the Corps of Royal Engineers may also, if desired, be supplied by Mr. HOWLETT, of the office of Inspector-General of Fortifications.

LONDON, *March* 5, 1853.

LONDON:
BRADBURY AND EVANS PRINTERS, WHITEFRIARS.