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PAPERS

ON SUBJECTS CONNECTED WITH

THE DUTIES

OF THE

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PREFACE.

It is due to the Subscribers to this Volume to state that, although it contains only five papers relative to the operations of the war lately terminated, every effort has been made to obtain Notes on this subject, the interest in which is so much increased by reflecting upon the large number of our brother officers (viz., fourteen), who have fallen during its continuance, of whose gallantry and science such records form lasting memorials, whilst they also afford glorious examples to those who remain, as well as most valuable guidance to enable us to profit by the experience gained in actual warfare with the arms and missiles employed at the present time.

The Official Journals of the Operations in the Crimea are not yet ready for publication, and the almost unprecedented and harassing amount of duty in the trenches, consequent upon the smallness of the number of our brother officers present, has probably prevented their writing any Papers on the subject for this Volume.

P. J. BAINBRIGGE,

Captain, Royal Engineers.

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MEMOIR OF THE LATE MAJOR-GENERAL COLBY,

ROYAL ENGINEERS, L.L.D., F.R.S.L. AND E., M.R.I.A., F.G.S., &c., &c.

WITH A

SKETCH OF THE ORIGIN AND PROGRESS OF THE BRITISH TRIGONOMETRICAL SURVEY.

BY COLONEL PORTLOCK,

R.E., F.R. AND G.S., F.R.A.S., AND M.R.I.A., ETC.

To close the Memoir of this distinguished member of our profession, it is now only necessary to consider him as a man of science, in reference to those operations of the survey which, like the observations of the practical astronomer, are classed together as scientific labours; and in this respect also it will be found that General Colby was not wanting in his efforts to maintain the high character of the British Survey, not only as a work eminently faithful in all its details, but also as having been marked by originality and boldness in its mode of execution. The origin and history of the British Survey have been already fully described in the first part of the Memoir; but for the present purpose it is necessary to take a wider range, and with the aid of the excellent article on the Figure of the Earth, by the Astronomer Royal, in the Encylopædia Metropolitana, to sketch briefly the general history of those scientific operations which, undertaken for the objects of the philosopher, have everywhere terminated in practical works of the highest importance; namely, in topographical surveys of the ground which either have already, or will hereafter, become powerful instruments of national improvement. Familiar as almost every civilized inhabitant of the earth now is with its general form, as a nearly spherical planetary body, it may be fairly said that the first man, who not merely recognised its rotundity, (as several phenomena celestial and terrestrial may have led to at least a suspicion of that fact,) but who, occupying only a speck upon the earth's surface, formed the bold design of attempting to measure it, must have been under the impulsive influence of a species of inspiration. The principle of determining the dimensions of the earth by measuring an arc of the meridian, or, in other words, of measuring spaces on various portions of a meridian corresponding to observed differences of altitude of the celestial pole, or of some heavenly body such as the sun or a star, and hence deducing the space in each portion corresponding to one degree of difference of altitude, or determining, as it is called, the length of a degree on the earth's surface, was that adopted by the Alexandrian astronomers, and has continued to be employed ever since.

Eratosthenes, about 230 B.C., observed that the sun was exactly vertical at Syene, in Upper Egypt, at noon on the day of the summer solstice, as the edges of a deep well threw no shadow on the bottom; and that at Alexandria the sun's zenith distance at the same season was 7° 12′, as measured by a vertical style fixed in a hemispherical bowl. He supposed the two places to be in the same meridian, and reckoning the distance at 5,000 stadia, estimated the earth's circumference to be 250,000 stadia; but, as the length of the stadium used is unknown, this curious though imperfect operation serves only as a record of the lofty conception of its author.

Posidonius, contemporary with Pompey the Great, (about B.C. 50) made a rough guess, much inferior in accuracy to the operation of Eratosthenes. He observed that the star Canopus just touched the horizon at Rhodes, when at Alexandria he estimated its altitude to be 7½°. The distance between these places he supposed to be 5,000 stadia, and hence estimated the earth's circumference at 240,000 stadia; but as refraction was then unknown, and therefore not allowed for, and no accurate estimation of the distance between two places separated by the Mediterranean could be formed, the measurement can be only considered a very rude operation.

Ptolemy, A.D. 137, makes no remarks on the dimensions of the earth, but he cites the fact that eclipses of the moon are seen at different times as regards the noon of the places of observations at different points on the earth's surface, these places lying east or west of each other, as a proof that the earth is spherical; and as he states that the differences on the earth's surface are proportional to the differences of apparent time, he may be considered as the first who suggested the principle of determining terrestrial longitude by lunar eclipses. Ptolemy also remarked, as a proof of the earth's sphericity, that on going northward the number of visible circumpolar stars is increased, which could not be the case, had the earth's surface been either cylindrical or a plane. He adopted 500 stadia as the measure of one degree, an estimate supposed to have been made by Marinus, the Tyrian, from observations of distant latitudes, compared with the rough measures of distance made by sailors.

A long interval now succeeded without any renewed attempt to measure the earth, when at length the Caliph, Abdalla Almamoran, who began his reign at Bagdad, A.D. 814, selected a spot on the plains of Mesopotamia, and directed one company of astronomers to proceed northward from that point, and another southward, until each should find a difference in the latitude, or altitude of the pole, of one degree, the distance being measured by rods. One party found the distance, or length of a degree, 56 miles of 4,000 cubits, and the other 56⅔; but as the true length of the cubit is not known, this measurement must also be considered only a scientific curiosity. Another period of 700 years had elapsed, when Fernel, a Parisian, published, in 1528, the account of a measure made in the neighbourhood of Paris. On August 25, he observed the sun's meridian altitude at Paris, and going northward one degree, as nearly as he could judge, he again, on August 29, observed the sun's meridian altitude. His angles were measured with a triangle, not a quadrant, one side of which, 8 feet long, was kept vertical, whilst another provided with sights was moveable round the point of connection with the first, and the third side being connected with, but moveable on the other sides, and graduated as a line of chords to every minute of the quadrant, served to measure the angles. The distance was calculated from the number of turns made by the wheels of Fernel's carriage, and the length of the arc he deduced was 56,746 toises, a remarkable approximation to the results of modern observations which is about 57,060 toises.

Snell published at Leyden, in 1617, the result of a measure remarkable as being the first in which the distances were determined by trigonometrical operations instead of by direct measurements with rods or perambulators. He measured a base of 326·4 Rhinland perches, and two bases of verification of 348·1 and 166 perches, the perch being 12 feet, and measured his angles with quadrants and semi-circles. From the distance between Alcmaer and Bergen-op-Zoom, as thus determined, he deduced the length of a degree = 28,473 perches, and from the distance between Alcmaer and Leyden = 28,510, and he finally adopted 28,500 perches as the length of a degree.

As Snell had carefully compared his standard with those of other nations, his measure was easily reduced to French toises, when it gave 1° = 55,100, and after the re-observation and re-calculation of the latitudes by Muschenbrock, in 1729, 1° = 57,033 toises: a proof that this early operation was conducted with great ability and care.

In 1637, Richard Norwood published the account of his measurement, being the first by an Englishman, with the exception of Wright's inference of the semi-diameter of the earth from an observation of the dip of the horizon at Mount Edgecombe. By means of a sextant of more than 5 feet radius, he determined the difference of latitude between London and York to be 2° 28′, and the distance between the two places he determined, partly by measuring along the road with a chain of 99 feet, taking the bearing of each line with a circumferentor and reducing these lines by a table, and partly by pacing. From these data he found 1° = 61,199 fathoms.

Riccioli's trigonometrical measurement in Italy was effected about this time, but his measure was very erroneous. His method of determining the arcal distance between two stations, was by observing the depression of each from the other.

In 1669 Picard commenced his trigonometrical measurement, which notwithstanding an error of six toises in his base and some other defects, may be considered superior to any which preceded it, and is especially remarkable, as having been the measure used by Newton in his Principia, published in 1687. The extremities of Picard's arc were Sourdon, near Amiens, and Malvorsine, near Paris. His base was 5643 toises, and his base of verification 3902. The difference of latitude between Malvorsine and Sourdon was found to be 1° 11′ 54″, and between Malvorsine and Amiens, to which the arc was extended, 1° 22′ 55″, the corresponding arcs being 68,439, and 78,850 toises, the first of which gave 1° = 57,064 toises, and the second 1° = 57,057, or a mean value of 1° = 57,060 toises = 60,812 fathoms. Maupertuis, Clairaut and others, having repeated the astronomical observations in 1739, the value of 1° was found to be 57,183 toises.

As already observed, Picard's measure was used by Newton, and confirmed the theory of universal gravitation, by reconciling it to the lunar motions, the consideration of which Newton had been obliged to lay by for a time from the want of such a measure, as he was not aware of the measures of Snell and Norwood, and assumed a degree to be 60 miles, as it was then commonly reputed to be. It is impossible not to feel additional admiration at the intellectual pre-eminence of Newton, when it is remembered that he was thus obliged to look to Flamstead for the celestial observations, and to take from Picard the terrestrial data, necessary to enable him to demonstrate that the grand conception of universal gravitation is a mathematical truth. In 1673 the doctrine of centrifugal force was first satisfactorily explained by Huygens, and combining this theory with the properties of fluids, Newton showed that the earth is not a sphere but a spheroid; that its equatorial diameter is longer than its axis of rotation; and that, supposing the earth to have been in the state of a homogeneous fluid, the proportion of the diameters may be taken as 229 : 230. Well might the work "The Principia," published in 1687, which contained such daring enquiries and such noble results as these, be looked upon as something more than human. In 1690, Huygens published his Treatise "De Causa Gravitatis," and assuming the attraction upon every particle to be directed towards the centre, and to be always the same at equal distances from the centre, a supposition opposed to Newton's principle that every particle attracts every other particle, he found the ratio of the axes to be 578 : 579.

It is rather curious that Svanberg, (1805), by confounding together the two works of Huygens, makes these latter deductions precede those of Newton. His words are, "The first results of the theorem (the dynamical theorem respecting centrifugal force), announced by Huygens, were the inequality of the force of gravity under different heights of the pole, from which, in consequence of its diurnal motion, it was necessary that the earth should have a protuberance towards the equator and be flattened at the poles. These discoveries were precursors of the hypothesis of universal gravitation, or attraction, afterwards proposed by Newton: a hypothesis which has entirely changed the aspect of Astronomical science, and from which must be dated the ever memorable epoch of the birth of "Physico-Mathematical Sciences." Newton however had conceived the sublime idea of universal gravitation, probably as early as 1666, and was only obliged to defer its elucidation and promulgation, until he had obtained a tolerably correct measure of a degree (that by Picard), on which to verify his calculations of the lunar motions.

At such a period in the advancement of human knowledge, some more powerful means of calculation became necessary towards the full development of the great physical theories, which from time to time began to present themselves to the human mind, and it seems as if an inspiration, similar in character to that which first suggested to Newton his noble conception of the great laws which bind the planetary bodies together and regulate their motions, must have also suggested to him a calculus suited to their mathematical representation, as it was at that time that he invented the Fluxional Calculus. This is not the place to enter into the controversy with Leibnitz on this subject, but though the differential calculus has now succeeded the fluxional, and been universally adopted by mathematicians as the most powerful instrument of the two, the fluxional bears upon it the stamp of originality, and could have sprung from no mind less imbued with the highest geometry than the mind of Newton was. Svanberg after describing Newton's theory that the earth is an ellipsoid of revolution, such as it would have become if supposed to have rotated in space when in a fluid state, observes, "The truth of the hypothesis of Newton was demonstrated for the first time by Maclaurin (1740) with that rigour which characterized his works, and which, so long as the taste for the exact sciences shall not be extinct in our enervated race, will secure for his 'Treatise of Fluxions' the glory of being one of the most sublime productions evolved from the constructive spirit of the ancient geometers."

It was only natural that such results, not merely expressing the magnitude but the actual form of the earth, should command the attention of philosophers; but they were soon doomed to be called in question. In 1684, J. D Cassini had commenced a trigonometrical measurement of an arc of meridian in France, having taken Picard's base as a foundation for his work, and proceeding thence southward. This arc was intended to form the basis for a general map of France, and the subsequent more accurate measurement of it was actually so applied; affording therefore an exemplification of the ultimate practical value of such operations, however purely scientific and philosophical may have been their primary object. This arcal measurement was completed in 1701, and a northern portion, extending to Dunkirk, in 1718. A base of 7,246 toises was measured near Perpignan, and one of 5,464 toises at Dunkirk. By the southern section of the arc was deduced $1^\circ = 57{,}097$; by the northern $1^\circ = 56{,}960$; a result tending to shew that the degrees became shortened in going from the south to the north, or that the earth was a prolate spheroid, the ratio of its axes being nearly 95 : 96. A deduction so entirely opposed to the theory and determination of Newton, roused the attention of Mathematicians, and as the Cassinis maintained the accuracy of the measurement and of the form of the earth deduced from it, the French Academicians proposed, and the French government supported, the design of measuring an arc near the equator, for comparison with that measured in France; and almost simultaneously it was resolved to measure another as far northward as possible; one of the most noble scientific schemes which had ever been projected being thus undertaken as one great whole. In May, 1735, Bouguer, Godin, and Lacondamine, sailed for America, and having crossed the Isthmus of Darien, proceeded to Peru, where, aided by some Spanish officers they effected the measurement of an arc of 3° in the great valley between the two principal chains of the Andes. The northern limit of the arc was $2\frac{1}{2}$° north of the equator, and the southern 3°, $4\frac{1}{2}$° south of it. The base of 6,272 toises was measured near Quito, near the southern extremity of the arc, and a base of verification of 5,259 toises, near the northern extremity, the lowest portion of this remarkable arc being $1\frac{1}{2}$ miles above the level of the sea, and some of the adjacent trigonometrical points differing from each other in altitude more than a mile. The physical difficulties of this measure, and the dangers from the ill will of the natives were very great, but the ingenuity and perseverance of the observers triumphed over them all The difference of latitude was 3° 7′ 1″, and the arcal distance measured 176,645 toises, whence 1° = 56,767 toises, or, reduced to the level of the sea, 56,748. The northern arc was measured by Maupertuis, Clairaut, Camus, Lemonnier, and Outhier, who arrived in the Gulph of Bothnia in July, 1736; they selected the valley of the river Tornea as the site of their arc, using the hills on each side for their stations, and after suffering much from cold, fogs, and other inconveniences, arrived after sixty-three days of fatigue at Kittis, a mountain selected as the northern extremity of the arc. On returning to Tornea, finding the river frozen, they measured their single base about the middle of the arc, when, not being quite satisfied with some of their results, they re-observed the latitudes and completed the observations of the three angles of some of the triangles, deducing as their final conclusion a difference of latitude = 0° 57′ 27·6″, an arcal distance of 55,023 toises, and hence 1° = 57,422. The latitudes were observed with a sector made by Graham; and in addition to the observations connected with the measurement, others were made, as in Peru, to ascertain the length of a pendulum vibrating seconds, all agreeing in showing that gravity increases in going from the equator to the pole, thus confirming the evidence of the arcal measurements. Whilst these works were in progress, J. Cassini, Cassini de Thury his son, and Lacaille had re-measured the French meridional arc, and by the aid of new bases and new observations had discovered the cause of the former difficulties, partly due to an error in Picard's base equal to $\frac{1}{1000}$ part of the whole, and which affected only one part of the arc, and partly to some inaccuracies in Cassini's work. From this new measurement it was found, that between Perpignan and Rodez 1° = 57,048$\frac{1}{2}$ toises; between Rodez and Bourges 1°=57,040; between Bourges and Paris 1° = 57,071, and between Paris and Dunkirk 1°=57,084. An arc of parallel was also measured across the mouth of the Rhone, the difference of apparent times, and hence of longitude, being determined by observing, from the two extremities of the arc the explosion of gunpowder, as a signal, fired from the top of a church intermediate between them, and the degree of this arc of parallel in latitude 43° 32′ was found to be 41,617·6 toises, whence comparing it with the arc of meridian between Perpignan and Rhodez, an ellipticity of $\frac{1}{178}$ was deduced. A comparison of the new arc of meridian, in France, taken as a whole, with the Bothnian or Lapland arc on the north, and the Peruvian arc on the south, showed that the degrees increased towards the pole, and therefore confirmed the Newtonian theory; but whilst a comparison of the French arc with the Peruvian gave an ellipticity of nearly $\frac{1}{314}$, a similar comparison between the Peruvian and Swedish gave $\frac{1}{213}$, shewing, provided all the measurements were quite correct, an irregularity in the figure of the earth which has since so much exercised the ingenuity of Geodesists, and led to the re-measurement of more than one arc. The Lapland arc was re-measured by Ofverbom, Svanberg, Holmquist, and Palander, in 1801, 1802, and 1803. In the Preface to the description of this work by Svanberg, M. Melanderhjelm, to whose exertions and influence with the King of Sweden must be ascribed the liberal manner in which it was carried out by the Swedish government, states "that it would be hard to give credence to the hypothesis of an irregular form of the earth; and as it must be admitted, if the former measurement should be proved to be correct, it appears only reasonable to endeavour, by renewed measures, either to establish the accuracy of the former results, or to correct them." In 1799, therefore, he requested Svanberg, Director of the Observatory of the Royal Academy of Sciences, who was about to visit his native country, in the vicinity of Tornea, to look after traces of the old arc, and to examine the mountains especially, in order to judge whether their attraction could have affected in any marked manner the sectorial observations. Svanberg considered, after a careful examination of the mountains, that no appreciable effect on the results could be ascribed to that cause, nor did he discover any other cause sufficient to account for the anomaly which the comparison of the previously measured arcs had brought to light. This report of Svanberg convinced Melanderhjelm of the necessity of new measurements, and backed by the representations of the Royal Academy of Sciences, he laid the case before the King, who at once in the most liberal manner sanctioned the project. Ofverbom, who was associated with Svanberg, was Chief Topographical Engineer in the Land Office. The Academy of Sciences took care, on Melanderhjelm's representation, to supply their delegates with the very best instruments they could procure; a repeating circle having been ordered for them from Lenoir of Paris, and made under the immediate inspection of Delambre. The French Institute also presented to the Swedish Academy a carefully prepared copy of both the metre and the toise, to be used as standards in the comparison of the measuring rods. The actual measuring instruments were iron rods, 6 metres long, to which further reference will be hereafter made. The summer of 1801 the astronomers devoted to exploration, and in January, 1802, provided with their instruments, departed for Lapland, from which country they returned in the month of March, 1803. The length of the arc measured was 1° 37′ 19·57″, between Mallorn and Pahtavara, and at the latitude 66° 20′ 10″ 05 1° = 57,196·16 toises; or supposing that the French double metre had not been regulated for zero, but for a temperature of 61¼ of Fahrenheit, 1° = 57,185·52. Again, using the refractions of Prony, instead of those of Bradley, in calculating his latitudes, Svanberg made the first of these results 57,188·43 toises, and the second 57,177·80; whilst it should be remembered that Maupertuis deduced from his measurement, 1° = 57,422 toises, being more than 200 toises in excess of the more modern measurement. In respect however to this measure, satisfactory as it appears in removing the difficulty which had before embarrassed the subject, Airey rightly remarks that it does not account for the difference between it and the old measure, as the geodetic measures of the two operations agreed very well, and the latitude of Tornea, determined by Maupertuis, agrees perfectly well with Svanberg's observations, whilst unfortunately the Swedish astronomer did not repeat the observations at Kittis, the only place where an important error could be expected to be found." Prior to Svanberg's measurement, the great geodetical operation of measuring the length of a quadrant of the meridian, passing through the Observatory at Paris, in order to determine the new standard of measure, which was to be the $\frac{1}{10,000,000}$ part of that quadrant, and to be called a metre, had been undertaken by the National Convention of Paris, and carried through by Delambre and Mechain, with instruments which will require a further notice hereafter. This great arc was measured amidst all the ferment of the revolution, and was therefore a work of no ordinary personal danger: it extended from Dunkirk to Barcelona, following, in fact, the course of the former arc, and was subsequently extended by Biot and Arago, to the Island of Formentara, near Minorca, and dividing the whole into five parts, of which this extension is the 5th, the values were, proceeding from the north to the south, $1° = 57,082·7$, $1° = 57,068·8$, $1° = 56,977·8$, $1° = 56,946·6$, $1° = 56,956·4$, and, further, the mean latitude of the whole arc, from Dunkirk to Formentara, is 44° 51′, and the mean length of a degree, 57,006·6. Now Svanberg, comparing his degree with the value of the Peruvian degree, deduced a flattening of $\frac{1}{331·45}$, and with the French degree, as determined by Delambre and Mechain, a flattening of $\frac{1}{326·89}$; and making the comparison with the Peruvian, French, and East Indian degrees, a flattening of $\frac{1}{323·06}$, the old anomaly disappearing.

For the present purpose it is not necessary to dwell on other arcs, such as that measured by Lacaille, in 1752, at the Cape of Good Hope, and subsequently re-measured by Maclear; the remarkable arc extending over about 100 miles, measured in 1764, by Mason and Dixon, in the present United States, with rods, without the aid of a triangulation; the very extended arcs measured in the East Indies, and alluded to in the earlier pages of this Memoir; and the minor arcs measured in Italy and other countries, as the object of this brief summary is not so much to give a general history of such operations, as to enable the reader to judge of the position maintained by British geodesists, in respect to their own arcal measurements and surveys.

Although great triangulations have since been adopted as preliminary operations in all national surveys, and the philosophical element, or that connected with the measurement of degrees, become secondary, or incidental, as it were, to the more practical one, such was not always the case; and, as before stated, the British, as well as the French survey, derived their origin from the philosophical operations directed to the determination of the figure of the earth. The origin of the British survey has been already thus explained, and it remains only to state, in respect to it, that as a work it was commenced with all the characters of originality, the genius of Ramsden supplying for its use a noble 3 feet theodolite, with which its terrestrial angles were to be taken, a still more splendid 9 feet sector for the astronomical observations, and the beautiful chain which replaced the rods, whether deal or metallic, with which other bases had been measured, or the deal and glass rods which were first and successively used on the British survey itself. Justly then it may be claimed for General Roy, the first conductor of this work, that he attempted to remove every chance of error, and to introduce an amount of precision scarcely then to be thought of; or in Airey's words, "we believe it may fairly be said that in this, as in other grand experiments, though we began later than our continental neighbours, we conducted our operations with a degree of accuracy of which, till that time, no one had dared to form an idea." At the time the British survey commenced, base lines had been always measured with some description of rods, and they were in consequence tried by our geodesists, but quickly abandoned for the chain, which may be called an English instrument, and for the number of years which elapsed from the commencement of General Roy's measurement to the preparations for the survey in Ireland, Ramsden's chains had been used in measuring bases wherever required on the British survey; but, in the interval, a new principle had been adopted by Delambre and Mechain in the construction of the rods used by them in the measurements required for proving the length of the metre; and this improvement ultimately led to the abandonment of the chain in the British survey.

In all simple rods or chains it was necessary to determine their length at some definite temperature, and to reduce the measure made at any other temperature to its equivalent at the standard one; hence, of course, careful observations were required and records of the temperature, as shewn by thermometers in contact with various parts of the chain, the reduction being then made consistently with the known experimental law of dilatibility of the substance of which the rod had been made. Without doubt very great accuracy was attained in this way, and as Svanberg even adhered to the system of simple metallic rods in his Lapland measurement, it may be well to describe and figure his apparatus as a late exemplification of this simple mode of measuring. The bars (Fig. 1) were strongly made of iron, 6 metres (19$\frac{3}{4}$ feet nearly) long, 1 inch wide, and 1$\frac{1}{4}$ thick, the ends A B C D, E F G H, being coated with silver, having a transverse line on each end, marking off the exact termination of the 6 metres; and calling these lines *a* and *e*, the line *a* of the second was made in laying the bars to coincide with the line *e* of the first, and so on successively. In using these bars it was necessary to guard against any alteration, except that due to change of temperature, such as alterations which might have been the result of their bending when moved along, and for this purpose a trussed plank Fig. 2. was contrived for the purpose, the screw G K passing through it admitting of the most minute adjustment. On the plank were fixed perpendicularly three brass plates, C, D, E, which supported the rollers on which the measuring rods were intended to rest. Through the plates were drilled small holes, *c*, *d*, *e*; a silk thread passing through them was stretched from *c* to *e*, and if found quite free in hole *d* proved that the three holes were in a vertical plane, and as the silk line must necessarily assume the form of a catenary, any variation in the positions of the holes by an alteration in the primitive flexure of the board would be at once detected, by the movement of the silk cord, upwards or downwards, in hole *d*. Svanberg enters into a detailed calculation of the probable amount of variation in the silk catenary, consequent on a varying flexure in the plank, and the effect of such variation and flexure on the length of the measuring rod, and ultimately on the length of the base, and states that after frequent comparisons during the measurement of the base, the versed sine of the catenary never varied more than $\frac{1}{25}$ of an inch, and that the whole correction on the base required by that flexure would not amount to that quantity, $\frac{1}{25}$ of an inch. The plate D was provided with a lateral micrometrical movement to adjust the line laterally. During the measurement the bars were compared with the standard double metre, Fig 3, No. 1; and to facilitate the comparison Svanberg adopted the following ingenious arrangement: two metal cubes, No. 2 and 3, were made and most accurately planed and polished, so that being brought in contact with the ends of the standard and firmly pressed by screws against them, they formed with the standard, as it were, one bar Fig. 4, the line of junction exhibiting a finer mark, or line, than could have been formed by cutting such a line on the surface of a bar. With beam compasses the length of the standard was then set off upon one of the measuring rods, and this was compared with the other rods by means of a curiously shaped compass, Fig. 5. The other details of this operation may be studied in Svanberg's account of it (1805); but it seemed desirable to give the preceding extracts, as being interesting illustrations of the contrivances adopted to ensure the utmost precision in the mode of measuring by simple rods or bars, which, after all, will be the method most generally adopted as being the most readily applicable to ordinary circumstances.

In the rods hitherto mentioned, the corrections for temperature required to be made from the observation of thermometers attached to, or in contact with them, the rate of dilatibility of the substance being known; but it is now necessary to consider rods which either measure their own change from temperature, or correct that change by their own movements; and for this purpose it is desirable to take a brief review of the history of pendulums, which, indeed, merit attention as being instruments which in one of their forms, have co-operated with arcal measurements in the determination of the figure of the earth. The discovery by Galileo of the isochronal property of the pendulum's vibration led to its application to clock work, and the priority of its use in this way has been disputed by Vincentio Galileo, son of the great Galileo, and by Huygens, the latter claiming to have made a really scientific pendulum clock before 1658, though Galileo may have made some rough experiments on the subject so early as 1649. The pendulum thus applied, however ingenious, was still subject to the variations consequent on changes of temperature, as the isochronism only holds good in circular arcs of the same degree of vibration; and the cycloid is the only curve in which the vibrations, whether short or long, are performed exactly in the same time. Huygens invented also an ingenious mode of making the pendulum vibrate in the cycloidal arc, but it has not been found practically useful.

The error in time, consequent on the changes in the length of the vibrating arcs, is due to the variations in the maintaining power consequent on alterations in the amount of friction; but there is another cause of error in time, due to variations in the length of the pendulum itself, consequent on changes of temperature. M. Lalande found that the length of a rod or bar of iron, forming a second's pendulum, was altered 0·178 of an inch by a change of temperature $= 67\frac{1}{2}°$ Fahrenheit, so that, being regulated in summer, it would gain 20 seconds per diem in winter; and it became necessary therefore, for all purposes in which precision was essential, to devise some mode of correcting or neutralizing the expansion and contraction; or, in other words, to contrive a compensation pendulum. Graham invented for this purpose the mercurial pendulum, which consisted of a steel rod 44 inches long, the lower end of which carried a large glass jar containing mercury, the diameter of the jar being about 2 inches, the height of the column of mercury $7\frac{1}{2}$ inches, and its weight from 10 to 12 pounds. In this manner, from the much greater rate of expansion of the mercury, the expansion of this small column counteracted the expansion of the rod and kept the centre of oscillation at the same distance from the centre of suspension. This form of pendulum was much improved by Mr. Frodsham, of the well known firm of chronometer makers, Parkison and Frodsham, who made such a clock for the College of Virginia in America, in conformity with the wishes of the late President Jefferson, the clock having been ordered by Mr. Peter Barlow, so well known to many of us, as one of our former most respected mathematical masters. The gridiron pendulum invented by Harrison, has, however, more connection with the present subject, and has, of all pendulums, been most generally adopted. It consists of nine round rods, five of steel and four of brass, arranged in one plane side by side, and made respectively of such lengths, that owing to the excess of expansion of one metal over the other, the centre of gravity should be moved upwards, notwithstanding the general elongation. The two outer bars are of steel, and being joined together by cross pieces at top and bottom, form an exterior frame; to the lower cross-piece are fixed two brass rods, within and parallel to the two iron rods, one on each side, their tops being connected by another cross piece, made free to move within the outer frame of steel rods; to this cross-piece is now attached a pair of steel bars within the brass rods, and both are joined together at their lower ends by a fourth cross piece which supports, as in the case of the first, another pair of brass rods, which are in like manner joined together at their summits by another cross piece, from which is suspended the fifth steel rod which carries the pendulum bob. Now, in this case, it is manifest that as the whole pendulum is suspended by the frame formed by the outer steel rods and their cross pieces, the expansion begins from the top and extends downwards, the steel rods carrying down with them the lower ends of the brass rods, the expansion of which may therefore be considered as commencing from below and extending upwards, so that the length of the rods being made inversely as their powers of expansion, the distance of the centre of oscillation from the point of suspension may, as in the mercurial pendulum, be kept invariable. In this case all the steel rods may be considered as expanding downwards, and all the brass rods as expanding upwards, and as these are arranged in pairs, with the exception of the centre steel rod, it may be said that three steel rods expand downwards and two brass upwards, the proportion therefore being as 2 : 3 ; but though five rods would thus be theoretically sufficient, nine are used in order to support equally the centre rod on both sides, so as to avoid twist and shock.

The several modifications of the gridiron form of pendulum are fully described in the article on manufactures and machinery, by Mr. Peter Barlow, in the Encyclopædia Metropolitana, to which reference may be made. The principle itself may be considered that of the measuring rods adopted by the French, though the object of their rods or bars was not to compensate for the variation of length due to change of temperature, but to measure its amount. The mode in which this was attained will be understood by reference to fig. 6, which however is simply an illustration of the principle, and not of the details of construction. Let *a* then be a flat bar of zinc, resting on and in contact with *b*, a similar flat bar of platinum, *a* being bevelled off at one end, and at the other connected with *b* by a screw. Now the expansion of platinum is only $\frac{1}{1167}$ part for 180° Fahrenheit, whilst zinc expands $\frac{1}{340}$ part for 180°, so that, between the freezing and boiling points of water, a platinum rod 20 feet long would expand 1·11 tenths of an inch, and a zinc rod of the same length 7·06 tenths, and in 90° the platinum rod 0·55 tenth of an inch, and the zinc 3·53 tenths; or generally, if n be called the expansion of the platinum bar, between the freezing and boiling point of water, $n + a$ may be called that of the zinc or other metal associated with the platinum, and the expansion in $\frac{1}{10}$ or any other proportion of the 180° $\frac{1}{10}n$, or $\frac{1}{m}n$, in the platinum bar, and $\frac{1}{10}n + \frac{1}{10}a$ or $\frac{1}{m}n + \frac{1}{m}a$ in the zinc. If then a scale be formed on the platinum bar 5·95, or 6 tenths of an inch nearly, in length, and divided into eight parts, each of these parts will represent the difference of expansion of the two metals in 10°. Now this scale commencing at the line formed at the end of the zinc bar, the two rods being then at the temperature of 32° as zero, and continued backwards also for about 10° of temperature, when the two bars begin to expand together, *a*, the zinc bar, will pass over one space for every 10° of change, so that, reading this change by a microscope, provided with a micrometer for subdividing the divisions of the scale into tenths and hundredths, the change due to one degree, or to $\frac{1}{10}$ of a degree, would be detected. The variations in the lengths of the platinum bar, corresponding to any changes of temperature, or in other words, to the difference of expansion or contraction, as shewn by the scale, namely, the $\frac{1}{m}n$, corresponding to the $\frac{1}{m}a$, being tabulated, the necessary reduction would be known at once by inspection. On this principle the French measuring rods were constructed, but it will at once be perceived that the friction of two bars, necessarily in close contact with each other, and their different times of heating and cooling may have occasionally had considerable influence on the results; still, however, the contrivance was very ingenious, and the arcal measurements of Delambre and Mechain, in which these bars and the repeating circle were the distinguishing instruments, must be looked upon as one of the most able works of the kind ever executed.

When the Irish survey therefore had been determined upon, it became necessary for its appointed chief, Major Colby, to consider whether he would continue to use the chain of Ramsden for measuring the new base lines, required as a foundation for that survey, or whether he should adopt either the French bars or some modification of them. This enquiry might not indeed have originated in another man, but Major Colby lived, as it were, in an atmosphere of science, belonging as he did to almost every scientific institution of the metropolis, and as, independently of the public meetings of such learned bodies, he dined three or four days a week, during the season, at their clubs, he was constantly engaged in hearing of and discussing the merits of the inventions of foreign countries. His active mind therefore became imbued, not only with a knowledge of what had been done, but with an earnest desire to advance still further the progress of geodetical science; and this ardent zeal, and craving for improvement, spread quickly amongst the young officers serving under him, and setting them also thinking and working, rendered the winter of 1824, 25, memorable in the annals of the survey, for the activity of mind and energy of purpose, which were so strikingly exhibited by the survey officers then in London, the head-quarters of the survey being the Map Office in the Tower. The officers who took a part, either by head or hand, in these proceedings, were Captain Mudge, Captain Robe, Lieutenant Drummond, and Lieutenant Murphy, all of whom have since died, the two first having attained the rank of lieutenant-colonel, and Lieutenant (now Lieut -Colonel) Dawson, Lieutenant (now Lieut.-Colonel) Larcom, and the writer of this Memoir. The quarters, in Furnival's Inn, of Lieutenant Drummond became a laboratory and a workshop, and diligently did that highly gifted officer labor to produce a measuring apparatus which should be free from the alleged defects of those hitherto used. His last and favorite scheme was a riband, formed of slips of mica, and which it was supposed would be almost invariable in length, from its very low degree of dilatibility. As however this riband would have required to be supported, like the measuring rods of Svanderg, by a trussed plank, and to be kept straight by weights, it did not appear to ensure permanency of length, even had it been admitted as true that mica undergoes little perceptible extension by heat. During his trials Lieutenant Drummond suspended the riband of mica by iron wires, but this system would not have answered in practice, as the expansion of the wires by heat would have affected their rigidity, and rendered different weights necessary for retaining them in one constant state of curvature. Encouraging his officers, as Major Colby did, to pursue these enquiries, and taking the greatest interest in the results of their efforts, he did not himself remain idle; and though, from his apparently careless manner, they scarcely looked upon him as a rival, the Master soon proved that in the race of invention he was able to beat even the most ingenious of his "Boys," as he familiarly called his officers.

It is necessary that I should here speak in the first person, in order to convey graphically the first steps of Major Colby's invention. Every one who knew him in those days must remember how rapidly he moved or ran through the streets, rarely relapsing into a simple walk; and it was thus that I met him rapidly descending Tower Hill, when he took my arm, and with the usual "Come my boy, I have something to talk to you about," carried me back with him to the Map Office in the Tower, which was not only the office for the business of the survey, including the engraving of the maps, but also contained the private apartments allotted to Major Colby, as director of the work. When once there I was detained for the evening, and after dinner Major Colby explained to me fully the idea he had formed of a compensation measuring rod. In the gridiron pendulum the motion of the centre of oscillation is the resultant of the motions of the two sets of metallic rods, the motion in one direction counteracting that in the other, and the resultant being therefore 0; in the mode proposed by Major Colby, two bars of different metals were to be fastened together in the centre (figs. 7, 8), and as the expansion or contraction of these bars would necessarily be in the same direction, the compensation was to be effected by connecting with them a transverse tongue *a′ b′ n′*, figs. 7, 8, 9, the bar *p a′*, fig. 7, expanding beyond the bar *q b′*, and necessarily producing rotation on the pivots *a′ b′*, fig. 9, as the tongue advanced to the position *c′ d′ n′*, or when it receded to that of *e′ f′ n′* in contraction, see fig. 7: the point *n′* being so adjusted that it should be kept, by this compound motion, always in the original line *a′ b′ n′*, when the bars are of the same length, that line being determined at some definite temperature, namely 32° or 60°, or 50°, which in this particular case appears preferable, as being about a mean temperature between the probable extremes in this country; in warmer countries the mean should be taken higher. This very beautiful principle is that of Ellicot's pendulum, though Major Colby was at the time quite unacquainted with this application of the principle. In Ellicot's pendulum the bars or rods of the two metals were kept in close contact by screws, fixed in the iron pendulum rod, which formed one of the bars, whilst the brass bar was permitted to move freely along the face of the iron bar, by slits wider than the body but narrower than the heads of the screws which played, as it were, in them. Immediately below the brass bar the iron bar was widened, and two steel levers, one on each side of the extremity of the brass bar, were pivoted into it, one end of the pivot turning in a socket formed in the iron bar, and the other end in a similar socket formed in an outer plate, screwed on to the iron bar. The pendulum ball was supported by screws, connected with the ends of the steel levers, and its weight depressing the long ends of the levers caused the short ends to press against the ends of the brass bar, so that when the two rods expanded together, the expansion of the brass exceeding that of the iron, the short ends of the levers were depressed and the long ends elevated, by which the pendulum ball was also elevated, and the effect of expansion, in lowering the ball, counteracted. Two differences between the pendulum and the measuring rods will be readily appreciated by the description here given; the first, that Major Colby kept his rods apart from each other, and thus avoided the effects of friction; the second, that in the pendulum the levers were only connected with the iron rod, and not with both rods, as in the measuring apparatus. In the pendulum, the levers turned freely round one centre, and there was no twist or distortion, whereas in the measuring rods, as the levers turn on two centres, fig. 9, it is evident that the ends of the bars, if tightly pivoted, will be pulled together whenever the line *a′ b′ n′* ceases, from the expansion or contraction of the bars, to continue perpendicular to them.

Having listened attentively to Major Colby's explanation of the principle of his proposed compensation measuring rods, I felt satisfied that it would succeed in practice, but such was not the opinion of all the members of our little senate, as Lieutenant Drummond was, in the first instance, more disposed to pursue his own enquiries, and expected a better result from them than from the proposed bars of our chief. I accompanied however Major Colby to the house of Mr Troughton, and when that first of British scientific mechanists had expressed his ready assent to the principle, and promptly offered to prepare a small model bar, there could be no longer a doubt of success, as every one who has had any occasion to consult Mr. Troughton well knows that he was not more distinguished for his high talent than for the frank and honest expression of his opinion. Some, doubtless, have at first felt mortified when some darling project has been overthrown by his abrupt " well, what is there in that?—there are many better things of the kind already;" but if so, they have at other times accepted his approval as the most gratifying and certain proof of merit in their designs, as he never flattered—never deceived. The small 3 feet model bar was rapidly made, and from that moment Drummond became the most able and active assistant of Major Colby, in conducting all the preliminary experiments. From the model bar Troughton proceeded without delay to the construction of a complete set of measuring bars, a ready assent having at that time been given by the Government, and especially by the Duke of Wellington, then Master-General, and by Sir H. Hardinge (Viscount Hardinge), then Clerk of the Ordnance, to any proposition of Major Colby for giving perfection to the Irish survey in every branch of its operations. The metals adopted were iron and brass, and each bar was 10 feet 1½ inch long, ½ inch broad, and 1½ inch deep, being placed 1·125 inch apart. Now let *a a'*, *b b'*, fig. 7, represent these bars, being united together at their centres by a steel bar *p q*, but allowed to expand freely towards the extremities, and let the brass bar, in expanding by a small increase of temperature, extend to *c c'*, and at the same time the iron bar to *d d'*, it is evident that the steel levers or tongues *a n* and *a' n'*, at the extremities of those bars, which move freely, but without shake, on conical pivots, which allow the tongues to deviate slightly from the perpendicular, without drawing the bars together in the manner before alluded to, will at the same time pass from the perpendicular positions *a b n*, and *a' b' n'* to the inclined *c d n*, *c' d' n'*, and *n n'* will remain at the same distance apart when the points have been so arranged that *a c* : *b d* :: *a n* : *b n*, or the expansion of the brass : the expansion of the iron :: the distance from the compensated point *n* to the pivot of the brass bar : the distance from the compensated point to the pivot of the iron bar. The two bars are placed in a box *e g f h*, fig. 8, on the bottom of which are fixed plates, at ¼ and ¾ of the length, to hold the rollers *r*, *r'* which are intended to support the bars, whilst at *t* there is a vertical brass stay which rises between the steel cylinders *s s'*, by which the bars are tied together, and thus prevents any accidental movement of the bars in a longitudinal direction. The tongues are secured from injury by a species of nozzle attached to the box at *o o'*, having a small circular opening provided with a lid, through which the compensated point may be seen; and at *i*, attached to the brass bar only, is a long level which is observed through a glass window forming part of the lid of the box; *m m'* are two pieces of metal fixed over the rollers which support the bars, and intended to prevent them from being thrown by any sudden jar against the lid of the box; at each end of the box, on the outside, is screwed a thick metal plate, for the purpose of firmly fixing a three armed grooved stand, intended to support the tripod of the compensation microscope, by which the connection between successive rods is made, see fig. 11; and for putting the bars approximately in line there is a vane sight at each end of the box, which is turned down, when not in use, on its hinges, into grooves.

The mode of placing the rods may be seen in fig. 11; first there are the pickets P P, P' P' driven into the ground at proper distances, and in the proper line approximately; the pickets are placed three and three together, and their heads levelled so as to support triangular frames R R'; on the frames are placed the " trestles " T, and on them tripods L L', which are adjusted into line by a directing telescope, and carefully levelled in respect to each other, and laterally also, so that when the bars are laid upon them they shall require as little adjustment as possible. On the tops of the tripods are rollers for supporting the bar box, and one is provided with adjusting screws for moving the box longitudinally, laterally, and vertically; the tripods are technically called camels. Six of these bars were used in the field, being designated A, B, C, D, E, G, and the weight of each bar with its brass ends is 136 lbs. In ordinary rods, the usual mode of connecting them in series, was either by actual contact or by the coincidence of lines, as in Svanberg's rods, but as these methods, or any modification of them, are subject to accidental disturbances, Major Colby determined to make the connection visually by means of connecting microscopes. These, as shewn in fig. 11, consist each of a central microscope or telescope, as it is called, with a microscope on each side, the lateral microscopes being connected with the central one by a compensation apparatus similar to that of the bar, but so adjusted that the outer focal point of the object glass shall become the compensated point. The object of this arrangement may be understood by the figure 11, which exhibits the telescopes M, M′, in action, either observing the dot on the first point-carrier, as it is called, Y, or transferring the point to the second point carrier Y′, in the first case commencing, as it were, the measurement from the point where measurement had ended on the preceding day; and in the second, recording on the point-carrier the termination of the measurement of one day, to be taken up on the next in a similar manner. The telescopes admit of a variation of focal length, to a reasonable extent, so as to meet the contingencies of moderately uneven ground, which in this case is presumed to be rising in advance of the higher point, Y′; and it may be observed that it is always desirable to leave a moderate number of point-carriers along the line, especially at points where any difficult piece of ground either commences or ends, so that a re-measurement may be made of any doubtful portion, without the necessity of repeating the whole work. If fig. 11 be considered the first bar of a new section, and the second or high point-carrier be removed, the bar will be in its proper condition for commencing, each succeeding bar being provided with a microscope only on the further end. The distance between the centres of the two outer microscopes, or the compensation microscopes, is 6 inches, and, of course, the distance from the centre of the inner, or telescopic microscope, to that of either of the others is 3, so that six inches require to be added to the length of every bar used in succession on any one day.

Seven microscopes were used, distinguished by the letters M, N, O, P, Q, R, S, the weight of each being 5 lbs. Messrs. Troughton and Simms also constructed two standard measures of 10 feet, formed of bars of wrought iron 122 15 inches long, 1·45 inches broad and 2·5 inches deep, which were placed, like the measuring rods, in boxes, and supported on rollers in a similar manner, to avoid any influence, either from friction or from surface contact, upon the expansion or contraction. These standards were cut away at their ends to half their depth, so as to place the dots about the neutral axis, in order to avoid, as much as possible, alteration of position from flexure. The distance of 10 feet was set off upon these standards, when at the temperature of 62° Fahrenheit, the terminating points being marked on platina pins, let into the iron bar, so that all comparisons were required either to be made at that temperature or their results to be reduced to it. In making any comparison with the standard, as for example, one with the compensation measuring bar after an interval of disuse, or after any accident, the standard placed on tripods, resting on a wooden frame, was brought into such a position that the end points should come into the foci of two delicate microscopes, attached to solid stone pillars, isolated by construction from the surrounding floor; and the microscopes being thus adjusted to the dots of the standard, it was removed, and replaced by the compensation bar, or any other bar requiring comparison, when, should there appear any difference, the amount of it would be measured with the most minute accuracy by the micrometer, forming part of the microscope. The laborious experiments which were made for comparing the standards with the recognized standards of measure, for determining the exact position of the compensated points of the measuring bars, and for examining various descriptions of varnishes in order to fix upon one which would equalize as much as possible in the two metals the times required for acquiring any change of temperature, (a matter of the utmost importance, as upon that equality depends the perfection of the compensation action, whilst the rapidity of heating and cooling is very different in different bodies,) were carried on by Lieutenant Drummond, assisted principally by Lieutenant Murphy, who died at Bussorah after the successful termination of the Euphrates expedition, but occasionally by several of our little band, under the immediate eye of Major Colby, on the basement floor of the Ordnance Map Office. The result was everything which could be desired, and the base of the Irish survey was measured on the extensive plain at the foot of the Benevenagh mountain, and between it and Lough Foyle, under the immediate direction of the inventor of the bars, in the summer of 1827, with the most perfect success, several portions of the measurement having been witnessed by some of the most eminent scientific men of the country.

It is to be regretted that Major Colby could not have devoted his time immediately to the publication of the details of this beautiful operation, and have thus connected his own name *alone* with a work so eminently his own; but at the moment the pressure on the survey, as regarded its more immediately practical results, was beginning to be felt, and it is not surprising that he found it necessary to devote his sole attention to the realization of the hopes of the public, by hastening on the more simple topographical work, and the preparation of the 6 inch maps, so urgently required for the use of the Valuation Commission. Yet, making this fair allowance for a first delay in publishing an account of the measurement of the base line, and also for the difficulties imposed upon Major Colby by the removal, first of Lieutenant Drummond, who was called upon by the Government to enter on those political duties which he so ably performed, first, on the Reform Boundary Commission, then as Private Secretary to Lord Althorpe, and finally as Under Secretary in Ireland; and again of Lieutenant Murphy, who was required to take charge of the scientific operations of the Euphrates expedition, under Colonel Chesney, R.A., as these two officers had been more concerned in the preliminary experiments and subsequent operations connected with the measurement than any others, it must still be admitted that the protracted delay of so many years was due to a constitutional defect in Major Colby's character, as in him, that which in moderation would have been a theoretical virtue of a high order, became, in excess, a practical vice. Major Colby, in fact, thought little of personal distinction, and as he looked upon the publication of the maps as the great object of the Irish survey, his attention became concentrated upon it, and, for a time, he almost overlooked that portion of his work which, though of comparatively less importance to the public at large, was *the portion* which would be most welcomed and appreciated by philosophers, and which was most fitted to elevate his character in their estimation. It was thus that whilst the townland survey began to move with giant strides, and to exhibit in all its movements an organization as perfect as that of the most admirably fitted machine, the remembrance of the scientific operations appeared to be gradually fading away into oblivion. Fortunately however the operations on the shore of Lough Foyle had been witnessed by too many men of science to allow them to remain barren of results; and soon afterwards Colonel Everest, then Surveyor General of India, being in England for the recovery of his health, applied to the Directors of the East India Company for authority to order from Troughton and Simms a complete set of Major

Colby's compensation bars for the use of the Indian survey, and with their usual liberality in all matters connected with science, the directors immediately assented. The bars were made, taken to India by Colonel Everest, used in verifying several of the preceding measurements, and actually first described by him in his account of those operations. In a similar manner Mr. Maclear, the Astronomer at Cape Town, applied for the use of the bars made for the first survey, to measure a base in Africa, preparatory to the operations for verifying Lacaille's arc, and they were taken to the Cape for that purpose, in charge of the late Captain Henderson, R.E., who had been one of the officers employed in measuring the base on Lough Foyle.

Before, therefore, Major Colby had published any description, however brief, of his measuring apparatus, he had seen it described by another officer of eminent scientific abilities, and employed both in Asia and in Africa, in verifying some of the most important arcal measurements which had ever been made, a practical triumph which was probably more congenial to the mind of Major Colby than any personal acknowledgment or testimonial would have been. At length, however, the omission was supplied, and, at the request of General Colby, an account of the measurement of the base on Lough Foyle, including a full description of the apparatus, was published under the immediate superintendence of Captain (now Lieut.-Colonel) Yolland. Though it is impossible not to regret that the inventor of the new measuring bars, and the conductor of the first measurement made with them, should not have published a work which describes inventions and operations so pre-eminently his own, yet, at the same time, the omission may be received as a powerful illustration of the total absence of selfishness in that remarkable man. So free indeed was he from that vice of little minds, and so ready on all occasions to recognize and give publicity to the merits and labors of his officers, that many people almost overlooked the commanding officer in their admiration of the subalterns; a feeling, indeed, so strong that for a long time Lieutenant Drummond was even considered the inventor of the very compensation bars of which he had, at the first, disapproved. Captain Yolland had not himself taken part in the Irish survey, but he had for some years been the executive officer of the Ordnance survey, had superintended the numerous calculations necessary for the task he undertook, and by the able description of the measurement of the Lough Foyle base already alluded to, as well as by the excellent Treatise on "Geodesy," in the third volume of the Academy course, has proved his sound knowledge of the subject, and his ability to support the character of a great National Survey. To these two works my brother officers must refer for further information on subjects which I have here dwelt upon, only so far as was necessary for recording the labours and delineating the character of General Colby.

The mental activity which was called into action at the commencement of the Irish survey was not exhausted in the one act of invention which has been described. It became also a question whether the old theodolite should still continue the sole instrument for taking angles, or whether the "Repeating Circle," invented by Borda, and ever since the favorite instrument of Foreign geodesists, or some modification of it, should be adopted in place of the theodolite, or in association with it. In the great theodolite of Ramsden, the accuracy of the great divisions of a large circle of 3 feet diameter, and the minute subdivision attained by delicate micrometer microscopes, were considered to be the surest means of obtaining accuracy of reading; whereas in the repeating circle, made comparatively small for the sake of portability, the errors of reading were sought to be compensated, or neutralized, by reducing the number of readings, necessary for several observations of the same angle, to two only. For effecting this purpose two concentric circles are used, capable of moving separately or being clamped together, the outer of which is graduated, and the inner

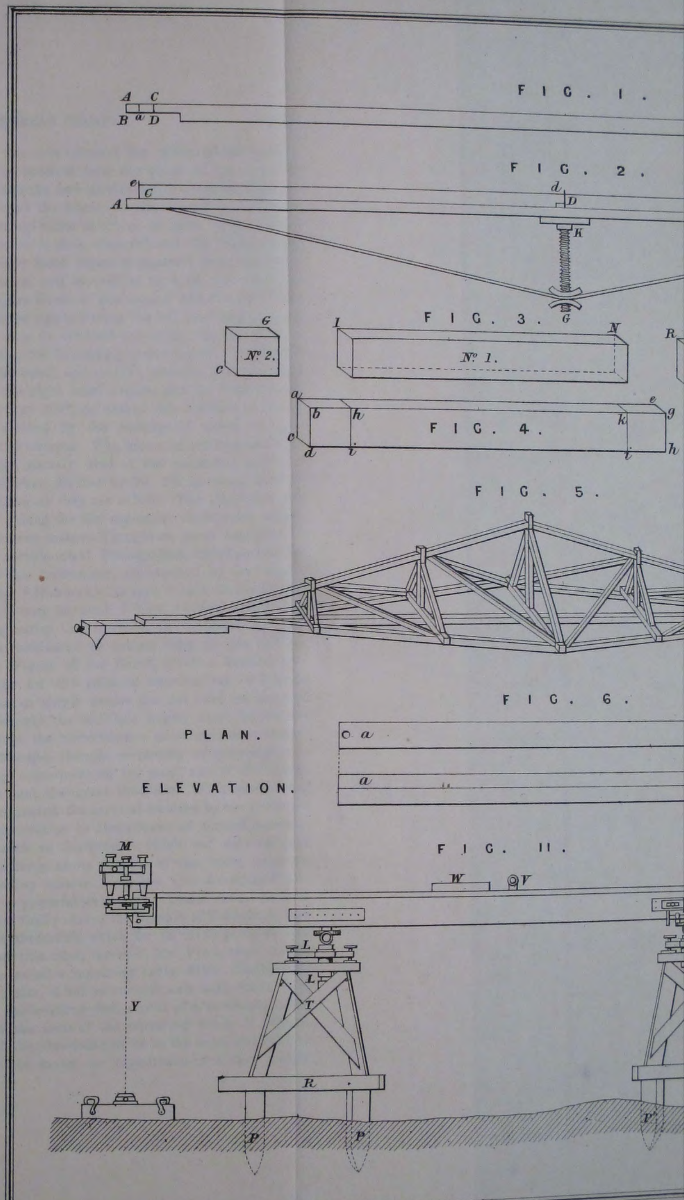


FIG. 1.
A
C
B
a
D
FIG. 2.
e
C
A
d
D
K
G
FIG. 3.
G
No 2.
c
I
N
No 1.
R
a
b
h
e
k
g
c
d
i
i
h
FIG. 4.
FIG. 5.
FIG. 6.
PLAN.
ELEVATION.
a
a
FIG. 11.
M
W
V
L
L
T
Y
R
P
P
P

carried the verniers and telescope. In this arrangement the plane of the instrument, when connected with its stand, is brought into the plane of the observer and of the two objects to be observed, and the two circles being clamped together are turned round on the common axis, until the telescope wires bisect the left hand object, the vernier of the inner circle being either at 0°, or at some other definite degree of the outer circle: the outer circle is then clamped, and the inner, being unclamped, is turned round until the right hand object is bisected, when the inner circle is again clamped to the outer circle, and instead of reading the angle, as in ordinary circles or theodolites, the entire circle is unclamped, and the combined circles moved backwards until the telescope again bisects the left hand object; and this operation is repeated as often as may be deemed necessary, the termination of the first measure of the angle becoming the beginning of the second; the termination of the second the beginning of the third, and so on; when at last the angle is read, the telescope finally bisecting the right hand object, and the whole space passed over, which may be either less than 360°, or exceed any number of times the whole 360° of the circle, being divided by the number of moves or repetitions, gives the actual angle between the objects. The errors of reading are thus restricted to the errors of two readings, namely, that at the beginning and that at the end, which become infinitesimal when divided by 10, 20, or more, according to the number of moves, or repetitions, as they are called. The simplicity and beauty of this contrivance immediately gained for the repeating circle many enthusiastic admirers; but our great instrument maker, Troughton, never approved of the principle, and in a Paper in the Astronomical Transactions, he expresses his opinion in reference to the defects of this instrument, consequent on the smallness of the telescopes connected with it. "However," he says, "an instrument may be constructed, or in whatever manner it may be used, I have no faith that it can give results nearer the truth than a quantity that is visible in the telescope," and Mr. Airey, the Astronomer Royal, is considered to concur fully in this opinion, having, indeed, in his Article on the Figure of the Earth, given a decided preference to the Sector, as an instrument for the celestial observations of a great survey. In truth, though the individual or single angles are not read in observations with the repeating circle, but simply the multiple angle, those angles *are observed*, and consequently must introduce the uncertainties or errors due to imperfect observations with an inferior telescope, though correcting or reducing to a minimum the possible errors of reading, consequent on the small size of the circle; and hence the comparison between it and the great theodolite of Ramsden was really between an instrument which corrected the error of reading by the principle of repetition, but left the errors of observation to the chance of mutual compensation, some being + and some —, with an instrument which not only reduced the errors of reading by the use of a large circle capable of the most accurate division, combined with powerful reading microscopes, but also diminished the errors of observation, by the use of a powerful telescope. Under these circumstances, it was not surprising that Major Colby shared the opinion of Troughton, and was not disposed to abandon the great theodolite, which for so many years he had handled with the greatest skill. About this time, however, Mr. Pond, then Astronomer Royal, had prepared what was called a repeating table, which consisted of a firm iron tripod, supporting, on a collar, a hollow conical axis with three arms at its summit. By this arrangement, the levelling foot-screws of a theodolite being received in grooves or cups fixed to the arms of the repeating table, it became possible, supposing the vertical axis of the theodolite to be in the same vertical line with the axis of the repeating table, to make the repetitions in a very simple manner; but to have effected the adjustment of the axes, supposing an ordinary theodolite to have been placed on a repeating table, would have been a matter of considerable difficulty, and the repeating theodolites which Major Colby ordered to be made on this principle required, therefore, a peculiarity of construction, the principle of which will be better understood on reading the description of the 2 feet theodolite presently to be given. Several of these theodolites, 12 inches in diameter, were made, but though unquestionably capable of doing good work, the general impression was that a mean of a moderate number of angles, taken with the theodolite alone, was fully equal in accuracy to the repeated angle obtained by using the repeating table in the same manner as the outer circle of the repeating circle, and the same was the general impression also, in respect to the observations made with a beautiful repeating theodolite by Reichenbach, which was purchased from Bouza, the Spanish Astronomer, then a refugee, and which is the very instrument described by Baron Zach. These instruments were destined for the District Triangulation, being the first step of the progression from the great triangulation, (the Division Triangulation being provided with 7 and 8 inch theodolites), and are without doubt, very beautiful instruments. The repeating table was applied to a more important instrument, expressly made by Messrs. Troughton and Simms for the use of the Irish survey, and intended to be applied more especially to the triangulation in immediate connection with the base line. In this instrument the divided circle is 2 feet in diameter, and the reading is effected by microscopes attached to strong conical arms which are connected with a central drum, on which rest the pillars which support the horizontal axis of the telescope, and to which the microscopes for reading the divisions of the vertical circles, connected, one on each side, with the telescopes, are fixed. In the interior of the drum is a hollow cylinder, accurately fitted to the vertical axis of the instrument, round which, together with its microscopes, telescope, &c., it turns. This vertical axis, which is made hollow, occupies the centre of the divided limb or circle, and is connected with it by six brass conical radii to which that circle is firmly attached. The vertical axis, which projects upwards, in order to form the axis of motion of the drum, projects downwards in the hollow axis of the repeating table, and there turns in a separate hollow cylinder, which is kept in its place by centring screws passing through the hollow axis of the repeating table. The levelling screws of the repeating table are received in cups attached to a triangular iron frame, which forms the top of the supporting wooden stand; and those of the theodolite, or more properly speaking, altitude and azimuth instrument, in cups attached to the arm of the repeating table. It will be observed by the description that all the vertical axes are made hollow, the object of which is, first, to place the repeating table, after having levelled it accurately, over the trigonometrical point by aid of a microscope temporarily fixed on the upper part of its hollow axis; and when this has been effected, and the theodolite placed on the repeating table and levelled, to place its centre also over the point, by the aid of a microscope screwed into the top of the drum, and looking downwards through the hollow axes of the instrument and table; the adjustment being in the latter case effected partly by means of the detached cylinder within the hollow axis of the table, and the centring screws, and partly by the collimating screws of the telescope. This delicacy of adjustment was necessary in an instrument intended to be placed over the delicate referring points of the base, in order to preserve in the angular measurements that minute accuracy for which provision had been made in the linear measuring. It is almost unnecessary to add that in this instrument the drum can be clamped to the divided circle, and in like manner that the hollow axis of the repeating table can be clamped to the collar of the tripod in which it moves; the circle, therefore, always moving with the repeating table, but the drum and microscopes being capable of independent motion, in this respect differing from the theodolite of Ramsden, in which the microscopes are fixtures, or only moveable with the outer case, which can be turned round on the stand for the purpose of changing, as it is called, the arc, then in fact performing, though rudely, the functions of a repeating table, whilst the divided arc moves round with the telescope, being attached by strong conical radii to a vertical hollow cone, which turns round upon a solid axis. As the focal length of the telescope of this instrument is 2 feet, it evidently unites theoretically the advantages of the large circular instruments of Ramsden and of the repeating circles, providing at once for accuracy of observation by a powerful telescope, and for precision of reading, both by a divided circle of considerable magnitude, and by the use of the repeating principle; if, therefore, it has not fully realized the expectations of its able makers, the result may be considered a confirmation of the other objection urged against repeating instruments, namely, the difficulty of ensuring that perfect concentricity of motion should be at first attained and subsequently preserved, between the moving portions of the instrument and those of the table. Though it is almost impossible to give an adequate idea of this very beautiful instrument without a figure (see Vol. 3 Academy Course, Plate VIII.), this brief description was necessary in order to show that General Colby was fettered by no old prejudices, but endeavoured to introduce into the Irish survey every supposed improvement which had been adopted by Foreign geodesists, and to give it the fairest possible trial, by applying to its development the unrivalled mechanical ingenuity of Troughton.

Another important consideration was the nature of marks to be used, as objects for observation, and this again called forth all the ingenuity of Lieutenant Drummond. The usual objects were conical piles of turf or of stone, 15 or 16 feet high, or Staves, formed of planks, 20 or 25 feet high, and sometimes 1′ 6″ wide, which, in peculiarly favorable states of the atmosphere, could be seen distinctly 90 to 95 miles, but long intervals of time would necessarily intervene, when no satisfactory observation could be effected of such distant objects. In the first section of the Memoir has been noticed, the ingenious contrivance of Major Colby, by which he reflected the sun's rays, on a definite line, from pieces of tin nailed on a staff, at angles corresponding with the varying elevations of the sun, and acting, therefore, for some days, as a true heliostat. This was probably the first application of the principle to geodetical operations, but just before the commencement of the Irish survey, Gauss had prepared two forms of heliostat, which were described by Baron Zach, and used in the Hanoverian survey, the account of which was published in 1820, and which as a survey deserves special notice, as the celestial observations for determining the amplitude of the arc were taken with Ramsden's sector, lent for the purpose. These heliostats were simple and effective instruments, but the reflecting surface was very small, not being intended for use at very long distances. It is by no means certain that Lieutenant Drummond was aware of Gauss's inventions before he had prepared his own, although he was certainly cognizant of them very soon afterwards. In his first heliostat, the direction was determined by one telescope, which may be called the "pointer," and the motions of a mirror, connected with it by an arrangement of rods or thin bars, something similar to those of a pantagraph, were determined by a small telescope with which the attendant followed the sun, the mirror moving simultaneously with it; so that the rays, when the sun was observed through this telescope, were falling on the mirror in such a manner as to be reflected from it in the direction of the pointing telescope. This was a very effective instrument, but it was troublesome in practice, as it required constant attention, and the position of the attendant, when using the small telescope, was awkward. Lieutenant

Drummond therefore replaced it by another much more simple, in which the mirror, from 10 to 12 inches square, was connected with a stand by a ball and socket joint, so as to be readily turned in any direction. The line was now marked out on the ground, which must have been done with any form of heliostat, when intended for reflection to distances of upwards of 100 miles, as no directing telescope suitable for such instruments could have seen objects so remote, and a small flat brass ring being placed in the direction, at about 20 or 30 feet from the heliostat, the attendant had nothing to do but to move the mirror until the sun's rays illuminated fully the brass annular disc before him, when he was certain that the rays were proceeding in the required direction; and at short intervals of time, when he observed the face of the ring becoming faint, to restore it to its brilliancy by a slight move of the mirror. This simple and effective heliostat was used with great success, at distances exceeding 100 miles, such as from Precelly, in South Wales, to Kippure, in Wicklow; the Keeper, in Tipperary, to Culcagh, in Fermanagh, and was so easy of management that it was put in position, and adjusted at Cnocanafrion, by Mr. James Flanagan, (a very intelligent civil assistant, then attached to the triangulation as a point-fixer) from measured distances, set off on lines to near objects, with which I had furnished him from calculation, a measuring tape and a common mason's level having been all the implements required for an operation apparently so delicate. Cnocanafrion, in Waterford, was thus observed from Bartrigaum, in Kerry, a distance of more than 90 miles. The heliostat was made generally useful by reducing the size of the mirror to a circle of 4 or 5 inches in diameter, when the instrument packed with its directing ring in a leather case, slung over the shoulders of the point fixer, became portable, and at any station could be screwed on to the top of a stick, not only rendering low and obscure stations readily visible, but also *identifying* them, a matter of no small importance in extensive surveys, as the point fixer and the observer took care simultaneously to note and record the time of observation. I have been gratified to observe that this mode of reflecting the sun's rays to a definite point, known to every schoolboy, has been recommended by Mr. Francis Galton, the African traveller, as a useful aid to shipwrecked sailors when struggling on the ocean in a boat, and unable, from its lowness in the water, to attract the attention of passing ships. Without doubt it would be the surest mode of drawing observation on the boat, and for such a purpose a bright piece of tin, or of any polished metal, might, as in General Colby's first contrivance, be used as the reflector.

In addition to the heliostat, Lieutenant Drummond proposed to apply the property of lime, and several other substances, of becoming intensely luminous at a very elevated temperature, the light of lime being especially pure and vivid. This property had been applied before in the laboratory of the chemist, but Lieutenant Drummond had the merit of applying it first to geodetical and lighthouse purposes. The preparatory experiments were carried on, as usual, in the apartments of Lieutenant Drummond, and were watched with the greatest interest by all of us, as well as by several men of science not connected with our profession, amongst whom was the amiable Dr. Prout. Lieutenant Drummond soon perfected his apparatus with the aid of Mr. Simms, the lime being placed in the focus of a parabolic mirror, and heated by the flame of a spirit lamp, driven upon it by a blast of oxygen gas; and from that time the light has been commonly called the "Drummond Light," and the apparatus "Drummond's Light Apparatus." It was first tried in the long room of the Tower, a room 300 feet long, which was destroyed at the time of the great fire, in comparison with an argand burner of the best description, and Fresnel's lens, lent for the occasion by Mr. Stevenson (the Bell Rock Stevenson); and again at the Trinity House and at Purfleet. Captain Basil Hall thus describes a portion of these experiments, which he witnessed from the Trinity Wharf, Blackwall, in a letter to Lieutenant Drummond, who being at Purfleet directing them, could not himself observe the effect. "The next series of experiments was the most interesting and decisive of all: each of the lights above enumerated, viz., the single argand burner, the seven argands, and the French lens were exposed, one at a time, in company with your light, in order to try their relative brilliancy.

1st. In respect to the single argand, nothing could be more pitiable than the figure it cut, being scarcely visible, and of a dusky orange tinge, while your light was of the most intense whiteness.

2nd. In respect to the seven argands combined, they were certainly easily visible, but I should not hesitate to say that your light was at least six or eight times as conspicuous, while in brilliancy or purity, or intensity of light, the superiority was even more remarkable.

3rd. As regards the French lens and your light, the superiority was equally undeniable, though the difference in the degree of whiteness was not so remarkable; the French light, however, is so nearly similar to that from the seven argands, that the comparison of each of them with your light gave nearly the same results, and all equally satisfactory, on the score of your discovery."

For some time it was hoped that the Drummond Light would be adopted in our light-houses, but the practical difficulties, involving the manufacture of oxygen gas, has hitherto prevented the realization of this hope. On the survey it was used only at one station, Slieve Snacht, in Innishowen, which had baffled, (probably in consequence of its position so near to Lough Foyle, over the surface of which the visual rays passed) the observers at Divis, near Belfast, for the whole season, though the distance between the two stations was little more than sixty miles. On the top of this mountain, amidst the snows and intense frost of the severe November of 1825, Lieutenant Drummond established himself, manufactured his oxygen gas, put up his apparatus and exhibited his light, which at once dispelled the difficulty of the observers, as it was visible even in the daylight, and shone at night with planetary brilliancy and distinctness.

In addition to these various appliances, the plan which had been shortly before proposed by Baron Zach, as the means of obtaining great accuracy from a very small portion of actually measured base, was likewise adopted, both for the purpose of comparing successive portions of the measured base with each other, and for adding on to the measured base a portion which, extending over the uneven surface of the Magilligan Sands, could not have been measured with the same certainty of precision. This method consisted in turning over by triangulation, as it were, a measured piece of the base on the line prolonged, or of comparing in a similar manner one measured portion with another immediately following it. Taking the latter as an illustration, the method of proceeding is this: let ABC be a portion of the base measured, and AB = BC, now placing the theodolite, or altitude and azimuth instrument, at B, set off two perpendiculars on AB, one on each side, and as nearly as possible equal to AB, namely BD and BD′, then observing at A the angles BAD, BAD′, and at D and D′ the angles ADB, CDB, AD′B, CD′B, and further at C, if desired, the angles BCD, BCD′, the actual lengths of the perpendiculars BD, BD′ may be determined from AB, as a base, with great precision, and thence BC from BD and BD′ with equal precision. Many such comparisons were made during the measurement of the base, and were very satisfactory in their results: and in a similar manner the portion of the Magilligan end was added on to the measured base.

The subject also of the disturbing effect of unequal local attraction, due to variation in the density of the superficial crust of the earth, on the observation of zenith distances was not overlooked, General Colby having supported the geological examinations of Dr. Macculloch in Scotland, which were in part intended to facilitate the estimation of such attractions, and having, as pointed out in the first part of this Memoir, succeeded in determining the amount of error in some of the amplitudes which was strictly attributable to such a cause. Had he continued connected with the survey he would undoubtedly have persevered in such enquiries, and they have not been neglected by the present Director of the survey, who has directed the attention of the department to the determination of the local attraction of Salisbury Crag. The results of this investigation have been most ably calculated and analyzed by Captain A. Clarke, R.E., one of the survey officers, in a valuable paper read before the Royal Society, and which will be hereafter published in the survey records. Two remarkable papers in the Philosophical Transactions for 1855 will doubtless not be overlooked by Captain Clarke, in his investigations of this important subject, on the right understanding of which so much of the accuracy of arcal determinations must depend. In the first, by the Venerable Archdeacon Pratt, of Calcutta, on the attraction of the Himalaya Mountains, and the country beyond them, on the plumb-line, in India, it is shewn that, whilst the amplitude of the northern division of the arc, included between Kaliana and Kaliampur, as determined by astronomical observations at the two extremities is 5° 23′ 37″·06, when computed geodetically, on the usually admitted form of the earth, it is 5° 23′ 42″·29, the astronomical arc being in defect of the geodetical by 5″·23. It is next shown that the simple *geodetical* measurements could not be materially affected by mountain attraction; and attention is then directed to the determination of the actual amount of attraction of the masses supposed to operate on the plumb line in India; but for the ingenious methods adopted by Mr. Pratt, of dividing the country into compartments in relation to each point of comparison, arranging the space, called by him "Enclosed" space, and comprising all the compartments considered capable of exercising a perceptible action, into the "Known Region" and the "Doubtful Region," and estimating from the recorded and actual data of the first, and from the best published accounts of the latter, their respective masses, and hence their attractive forces, reference must be made to his paper, or to the abstract of it, in the Astronomical Society's proceedings. The results of the calculations would give a deflection at the northern, middle, and southern stations, called A,B,C, of 27″ 8·53, 11″·968, 6″·909 in meridian, and of 16″·942, 4″·763, 2″·723 in azimuth, so that the difference of meridian deflection between A and B is 15″ 885, and between A and C 20″·944, quantities greatly exceeding the error of 5″·236. After trying the effects of various hypothetical assumptions, Archdeacon Pratt was still unable to do away with the difference between the observed and the computed deflections, the latter still remaining in excess. At this point then the subject is taken up by the Astronomer Royal, in the Second Paper, in which he is necessarily obliged to found his reasonings on a hypothetical assumption, namely that the crust of the earth is about 10 miles thick, and rests on a fluid mass, called, for convenience sake, lava, more dense than itself. He then states that the effect of the pressure of a high table land, 2 miles thick and 100 miles across in its horizontal dimensions, resting on the earth's surface, would be to crack the crust below, and force the edges of the fracture into the lava beneath, so that, whilst the attraction above the crust would be increased, the attraction below would be diminished by the exchange effected between the heavier matter of the lava and the lighter of the crust forced into it. From this investigation, Mr. Airey comes to the general conclusion that the real disturbances will be less than that found by computing the effect of the attraction of the mountains, the differences in all cases being small at points near the elevated land, but very great, indeed, or nearly equal to the whole, at distant points. Let it be added that these ideas of the Astronomer Royal are of high interest in their bearing upon many most important geological questions.

The only other instance I shall quote of General Colby's anxiety to render the Irish survey perfect in all its branches, is the judicious manner in which he supplied the place of the celebrated 9 feet sector of Ramsden, which had been destroyed in the great fire which ravaged the Tower. The fault of that admirable instrument was its want of reasonable portability, as, in consequence, it became necessary to restrict the number of places of observation, and it was scarcely possible to shift the sector about in the manner required for testing the effect of local disturbing attractions. In this respect then, the repeating circle had a decided advantage, and Colonel Colby being therefore anxious, in replacing the old sector, to adopt a construction of instrument which should retain the advantages of the sector, and yet share with the repeating circle in the advantage of portability, turned to the Astronomer Royal for advice and assistance in planning the new instrument.

In the Preface appended by Colonel Hall, R E., then Superintendent of the Ordnance Survey, to Captain Yolland's account of the " Astronomical Observations made with Airey's Zenith Sector," published in 1852, the subject of this new instrument is thus noticed : " to the Astronomer Royal this department is deeply indebted for the valuable advice and assistance afforded by him on numerous occasions, both with reference to the use of the instrument, and the reductions of the observations ; and is wholly indebted to him for the design and superintendence of the construction of the instrument; for in the Autumn of 1841, Major General, then Colonel, Colby, R.E., my predecessor as Superintendent of the Ordnance Surveys, seeing the necessity for obtaining accurate latitudes of some of the mountain stations used in the principal triangulation of the United Kingdom, consulted the Astronomer Royal, G. B. Airey, Esq., with reference to the construction of a Zenith Sector, of a more portable description than Ramsden's, and of such a nature that observations made with it on a single night might be expected to furnish absolute zenith distances with great accuracy, instead of being dependant on observations made with an instrument usually placed in reverse positions on successive nights, or as frequently as the nature of the weather would permit ; and the Astronomer Royal, with his usual readiness to oblige, gave the subject his immediate attention, and accordingly proposed and subsequently superintended the construction of the instrument with which the observations recorded in this Volume have been made." The instrument is fully described by Captain Yolland, in the Volume to which reference has been made. The material used was principally cast iron, and the instrument was formed of as few parts as possible, each being cast in one piece, so as to avoid that pregnant source of deterioration sure to be found in numerous parts, each formed by the union of many pieces. The rectangular revolving frame, which carries the divided limb, is of gun metal, cast in one piece ; the telescope frame, also of gun metal, bears on a circular ring 9¼ inches in diameter, attached to the centre of the frame, and turns on a hollow circular pivot which passes through a corresponding circular hole 3½ inches in diameter in the centre of the frame. The divided limb consists of two arcs, each of 45°, placed 20½ inches from the centre of the frame, so as to form parts of a circle 41 inches in diameter, reading from 0° to 360°, the divisions being on silver. The focal length of the telescope is 46 inches, the diameter of the object glass 3¾ inches, and the magnifying power usually employed 70 ; the microscopes for reading the zenith distances are attached to the telescope frame. The revolving frame turns in azimuth on a vertical axis, formed by two conical pivots, connected with the external frame, one above and one below, and the telescope frame turns vertically on the horizontal axis before noticed, so that the work of reading, turning the instrument

180° in azimuth, and reading again, is effected with great ease and rapidity. In addition to this, the upper pivot of the revolving frame can be raised upwards by a screw, and the whole frame can be reversed, end for end; the divided arc, which was at first below, becoming then the upper arc. Instead of the plumb-line of the old sector, spirit levels, supplied with very accurately divided scales, were used in this instrument, of which the total weight was nearly 10¼ cwt. The system of clamping has not here been detailed, but so simple and perfect was everything connected with it, that in the hands of the officers of Engineers, and non-commissioned officers and privates of the Royal Sappers and Miners, (soon about, it is hoped, to share our name of "Engineers," as they have so long shared our labours and our dangers) a mass of accurate observations has been collected, such as perhaps no other survey in the world can boast of.

Let me here express an opinion and a hope, which, I trust, may attract the attention of some scientific member of Government, and lead to the realization of that hope. The bases of our own survey, the bases of the Indian survey, and the South African base, have now been verified in the most scrupulous manner by new measurements with the compensation bars, and the observations for latitude in our survey have been verified with Airey's Sector; surely then it would be worthy of Europe and America to encourage a similar verification of their own bases and their own observations for latitude, with the same instruments. The compensation bars and the zenith sector of Airey could be carried with ease to France or any other part of Europe, to Asia and to America, and having been used in verifying the old work, the comparison of arcs would be no longer made from measurements and observations effected by so many different instruments, but would depend on data in every respect harmonious and consistent.

To enable us to form a correct estimate of the scientific claims of General Colby, it may be well briefly to sum up, under two heads, the services by which it is considered that he materially advanced the progress, and raised the character of the British survey. 1st. When serving under General Mudge, he displayed that extraordinary degree of mental and physical energy, of endurance of fatigue, and of perseverance, which gave new life to the survey, whilst in all its operations he exhibited a remarkable skill in observing, which called for the admiration of foreigners, and was well known, and admitted to be first rate, by his own officers. 2nd. When at the head of the survey, he gave a new character to its scientific branch, by the invention or application of new instruments, he planned and matured an admirable system for the more practical portion; he took the highest view of the objects of a survey, looking upon it as a basis for National Improvement, and consequently as the ground work for Historical, Antiquarian, Natural History, Geological and Statistical Surveys, having thus commenced what his former able assistant, Lieut.-Colonel Larcom, has since perfected in the Statistical Tables prepared under his directions, as Under Secretary for Ireland; he encouraged the formation at the survey office, not merely of a Museum of Economic Geology, but of a Museum of General Natural History, recent and fossil, and though, under the influence and by the ability of Sir Henry De la Beche, the Museum of Economic Geology has since become a National Institution, and a National Triumph, it should not be forgotten that the Phœnix Park exhibited previously the germ of such an establishment; he endeavoured in every way to improve the artistic character of the maps, and he advocated the contour system, which sooner or later will overcome prejudice, and be adopted generally, with the same successful effect as that which has been so admirably attained by Mr. Mylne, in his Map of the environs of London. He was wise enough to know that such labours required the co-operation of men of great ability and perseverance, and the names mentioned in this Memoir prove that he exercised an admirable judgment in their selection; he was also generous enough not to use persons merely as instruments to elevate himself, but kept their scientific reputation equally, if not more, in view than his own. Can it then be doubted that he has an equal, if not a higher claim upon our respect and admiration than any of the remarkable men who have been connected with the survey.

A careful consideration of the facts which have been here adduced will justify us in dividing the History of the Survey into two great periods; namely, that of General Roy, which includes the time during which he, Colonel Williams, and General Mudge presided over it, and that of General Colby, which extended up to the present time; as the inventions and arrangements of Roy and Colby are characterestic of the epochs assigned to them. In the first part of the Memoir I have designated General Roy as an *Artillery* Officer, but in this I was not correct; and having since obtained some valuable information on the subject from Mr. Marriott, the Manager of the Engineer branch of Cox's agency, so well-known to every member of the corps for the uniform kindness and consideration he has ever manifested, as well to the youngest as to the oldest officer, I think it right to render my Memoir of the able first leader of the survey complete by inserting it, more particularly as the information is of general interest to the corps.

The French Corps du Génie was first called into being by the great Sully, the Minister of Henry IV., and was composed of the most able officers which could be collected together for the purpose; and the British Corps of Engineers was first formed in a similar manner in 1757. Before this time there had indeed been a Corps of Engineers, but, like that of Military Draughtsmen, it consisted of *Warrant* Officers. William Roy was one of those selected for the new corps, having already belonged to the previous corps, as his name appears as Practitioner-Engineer in the Army List of 1756. He became Practitioner-Engineer and Ensign of the New Corps of Engineers, May 14, 1757; Sub-Engineer and Lieutenant, 17th March, 1759; Engineer in Ordinary and Captain, also in that year; but there appears some confusion as to the precise date. The date of the intermediate step, if he ever held it, of Engineer extraordinary and Capt.-Lieutenant, is not known. He was Director and Lieut.-Colonel of Engineers, 1st January, 1783; Director and Colonel, 16th Sept., 1785. In the Army he was Lieut.-Colonel, 23rd July, 1762; Colonel, 29th August, 1777; Major-General, 19th October, 1781. He was Deputy-Adjutant General in 1764, 1765; Deputy-Quartermaster General in 1766, and was appointed Colonel of the 30th Foot, 15th November, 1786. This statement is of the highest importance at the present moment, as it indicates the high estimate which was originally formed of the qualities which an Engineer officer ought to possess. They were indeed in the first instance, and for many years afterwards, as in France, selected from the Artillery and from any other quarter where high intelligence had been manifested, as may be well illustrated by the case of George Morrison, who was Lieut.-Colonel in the Army and Quarter-Master-General in 1761, but became Engineer in Ordinary and Captain of Engineers in 1766; and, after attaining the Engineer rank of Major and Sub-Director, left the Corps, and as Major-General, became successively Colonel of the 17th and 4th Regiments of the Line. They were, in the cases of General Roy and of several other of the earlier officers, employed in the most confidential posts of the General Staff of the Army, and even promoted to the command of Regiments of Infantry. The teaching of such experience ought not be thrown away, as it will certainly be found hereafter that should an attempt be made, either to amalgamate the Artillery and Engineers, or to deprive the latter of their high military character, the immediate result will be a practical disappointment, and the future result a restitution of the corps to all its individuality and intellectual pre-eminence. General Roy was selected as first director of the survey, not because he was an officer either of Artillery or of Engineers, but because he was a man of well-known scientific abilities; his successors, Colonel Williams and General Mudge, were officers of Artillery, but they, too, were selected for their supposed fitness, not for their Army position; and in like manner Captain Colby, an officer of Engineers, was selected because the Duke of Wellington, assisted by the opinions, not of Heads of Military Departments, but of scientific men, considered him the best man for such an office. The survey was then an independent work, and General Colby being, as its Director, responsible only to the Master-General, thought himself justified in requiring the services of officers of Artillery, as well as of officers of Engineers, and, in consequence, for several years he employed on the Irish survey the late Lieutenant-Colonel Robe, R.A., a most able surveyor, and also Lieutenants Rogers and Mallock; but he was soon obliged to restrict himself to officers of Engineers, as the authorities of the Artillery declared they could not spare their officers for such a service, and required them to return to their ordinary duties.

The more complete military organization which Colonel Colby proposed for the Irish survey, and the consequent employment of a large body of Sappers, gave a new character to the Survey Establishment, and ultimately led to its absorption into the general body of the Engineer Department. The loss of that independence, and of the dignity which naturally belonged to the head of a department at once so important, so scientific, and so totally unconnected with ordinary military duties, was unquestionably severely felt by Colonel Colby; but he continued to superintend the survey until he became a general officer, when the ordinary rule of the Engineer Department was applied to his case, and as it is technically called, he was put upon the shelf, and replaced as superintendent by another officer who had never before been employed in the survey. With the warmest attachment to my own corps, as a body of scientific officers, for it is only as such that it can ever hope to maintain its high position, and with the sincerest respect for the able officer who presides over it as Inspector General, I have never been able to think that the change in the character of the Survey Department was a judicious one; and I sincerely hope that it will now regain its independence, and enlist in its service the most able officers, whether of the Artillery, of the Engineers, or of the Line (for there is now no separate Ordnance Department) which can be found; and should there be any difficulty in effecting this restoration without still further change, let officers and men be classed together as Staff or Topographical Engineers, with rank and pay commensurate with the importance of their duties: and let the superintendent or chief be selected, as in former times, without reference to his peculiar corps, on the simple ground of recognized abilities, thorough knowledge of the science of geodesy, and fitness of character as regards energy and judgment, to conduct so great a work. I doubt not that my brother officers will generally attain this high prize of intellectual and moral eminence; but it is only as being deserving of it that I can wish to see them obtain it.

In the preceding pages I have, perhaps, said enough to pourtray the frank simplicity, the genuine, as being unostentatious, hospitality, the silent charity of General Colby, who, dreading the charge of weakness, gave secretly what he denied openly: but I am now enabled, from the following anecdote communicated to me by Lieutenant-Colonel James, R.E., the present Superintendent of the survey, to show that General Colby was also capable of exhibiting a noble munificence in his generosity. Whilst examining the Orkney and Shetland Islands, and selecting amongst them stations for the triangulation of the United Kingdom and for fixing the northern extremity of the British arc of meridian, as detailed in the first part of this Memoir, he was necessarily indebted to Lieutenant Thomas, R.N., then in charge of the hydrographical survey of those islands, in whose vessel he was conveyed from island to island, for most valuable assistance and for the greatest attention and hospitality. Services such as these, in a country so dreary, and in an ocean so stormy, were not only personally agreeable, but were essential to the successful performance of an arduous duty; and so deeply were they felt and valued by General Colby, that he presented Mrs. Thomas with the sum of £500 to assist her husband in the prosecution of a lawsuit in which General Colby had heard that he was then engaged. Lieutenant Thomas, on learning the circumstance from Mrs. Thomas, insisted on returning the money to General (then Captain) Colby; but he did not the less appreciate the noble spirit which had dictated the gift, nor fail to hand down the memory of it to his son, the present Lieutenant Thomas, R.N., who is now, in succession to his father, employed in the North and East of Scotland, and by whom the knowledge of this interesting fact was communicated to Lieutenant-Colonel James.

In the preceding narrative, General Colby has been generally, though not always, spoken of according to the rank which he held at the time of the event or act recorded; and it is therefore necessary to give a brief statement of the successive changes in his military position, in order to link together the several parts of the Memoir. His entrance into the Engineers, as Second Lieutenant, was in December, 1801; he attained the rank of First Lieutenant in 1802, that of Second Captain in 1807, and that of Captain in 1812; he became Major (by Brevet) in 1821; in 1825 he was promoted to the rank of Lieutenant Colonel, in 1837 to that of Colonel, and in 1846 to that of Major General. During the time thus passed over in review, several changes took place in General Colby's residence: at first he continued to reside at the Ordnance Map Office in the Tower, having appointed a local Director to represent him in Dublin, but it soon became evident that the new work required his personal presence more than the old; he therefore assumed the command in person, in Ireland, in 1828, and for ten years steadily directed the operations of the survey, from the Head Quarter Office, at Mountjoy House, in the Phœnix Park, the organization of which he had, with his usual forethought and judgment, confided to Lieutenant Larcom (now Lieut-Colonel), whom he had taken over with him for that purpose.

In 1828 he married Elizabeth, daughter of the late Mr. Boyd, of Londonderry, for many years the highly respected Treasurer of that county, and took a house in Mountjoy Square, where, being received as an inmate, after the Hill season of 1829, I had an ample opportunity of seeing him at his own fireside, and recognizing in him those domestic qualities which made every one happy and at ease about him; and I may add also that in Elizabeth Boyd he found a helpmate worthy of him; one, indeed, who, by her simple and unaffected kindness, proved that she entered fully into her husband's feelings, and made his friends her own. General Colby then took on lease Knockmaroon Lodge, close to the park gate of that name, and at the distance of a short walk from the office. Here, again, I was a visitor at his house, and saw the virtues of a warm heart still further expanded, as the General had then become a Father. My friend Lieut.-Colonel Larcom has said that though General Colby was like a rock, immoveable in a determination on points of duty when he had once decided, he was as gentle and kind as a father or brother when personally communicating with his officers and men; but to see and appreciate those qualities in the highest degree, it was necessary to study them in his own house, where the steady calm reasoner of one moment became, in the next, almost the giddy boy, when playing joyously and without restraint with his children; for, in truth, his greatest happiness was found in the quiet enjoyment of his own home.

It was during this residence in Ireland that he endeavoured to renew the project of a complete Hill-Drawing Department, for which purpose he availed himself of the unrivalled skill in that branch of work of Lieutenant (now Lieut.

Colonel) Dawson. The object appeared to have been fully gained, when, at the moment of success, Lieutenant Dawson was, as in the cases of Drummond and Murphy, removed from the survey, and appointed to an office of great responsibility in England, first in connection with the Reform Commission, and then with that for regulating the Tithes. This Department was, however, remodelled, and rendered even more effective by the introduction of the system of contours. In 1838, General Colby returned to England, as the development of the Scotch Survey then began to require his more immediate attention, and, in 1846, just at the moment when the map of *the last Irish County* had been given to the public, he quitted the direction of the work and retired into private life.

In respect to his connection with learned Societies, he was one of the original Fellows of the Astronomical Society, having assisted in framing the rules for its government at the period of its formation in 1820, and he succeeded General Mudge as a Member of the Government Board of Longitude. He was a Fellow of the Royal Societies of London and Edinburgh; and of the Geological, Geographical, and Statistical Societies of London; a Member of the Royal Irish Academy, and of the Geological and Zoological Societies of Dublin; an LL.D. of the University of Aberdeen, and a Knight of Denmark; and as regards the Institution of Civil Engineers, the words of its able Secretary, Mr. Charles Manby, will best show the estimation in which he was held by our civil brethren. "He became connected with this Institution, as an Associate, in 1820, and was transferred to the class of Honorary Members in the same year. He was much attached to many Members of the Society, very frequently attended the meetings, took part in the discussions, was always ready to afford information or assistance, and at every annual meeting the Council had the pleasing task of recording General Colby's unceasing attention and liberality, in procuring for and presenting to the Library, the Ordnance Maps and many other valuable documents, as soon as they were published."

On quitting the Survey, he retired to the Continent and devoted himself to the education of his sons, residing partly in Germany and partly in Belgium, but at length the unsettled aspect of affairs abroad induced him to return home, when with little or scarcely any warning, the Spirit, yet active, was summoned from the Body, yet firm and hale, and on the 2nd October, 1852, in the 69th year of his age, whilst amidst his loving and mourning family, at New Brighton, near Liverpool, he passed from the scene of so much bodily and mental exertion to rest and peace eternal.

Whilst living, General Colby received none of those honourable distinctions which so many prize far above pecuniary emolument; but it is gratifying to think that the Government has, since his death, recognized his great claims on the Public, and awarded to his widow a life pension.

My task is now completed, and I hope that I have been successful in setting before my brother officers a faithful picture of the services and character of a man who so long and so ably conducted the great surveys of this country. In my early connection with the Irish survey I was his chosen assistant and confidential adviser, and it was then I learnt to appreciate his accurate knowledge, his sound judgment, his untiring energy and consummate skill, and above all, his unbounded liberality in imparting to me and others the stores of his own knowledge. In the later period of my connection he was estranged in feeling towards me; but as I now look back at the past from a more distant point of view, I cannot doubt that there were faults on both sides. In short, I was once his favoured disciple, and feeling that the early kindnesses and services I received from him far outweigh the later harshness, which at the time I deemed injustice, I am proud to have had the opportunity of recording my respect for the memory of a man towards whom, when living, I had always felt and expressed affection.

J. E. P.

PROFESSIONAL PAPERS.

PAPER I.

Description of the Russian Works at Bomarsund, in the Aland Islands,

And Journal of the Operations which led to their Surrender in August, 1854,

Together with observations on the Subject,

By BRIGADIER GENERAL H. D. JONES, Royal Engineers.

(Printed by permission of the Inspector General of Fortifications.)

Journal of the Operations at the Siege of Bomarsund, in August, 1854.

The force assembled in Led Sund Bay consisted of the British squadron of line-of-battle ships and steamers, under the command of Vice-Admiral Sir Charles Napier, and the French squadron, composed in like manner, under Vice-Admiral Parceval Deschênes; and a French corps of troops, consisting of infantry, artillery, and engineers, forming a total of about ten thousand men under General Baraguay d'Hilliers. The only British troops, independent of the Royal Marines, were a company of Royal Sappers and Miners. Brigadier General Harry D. Jones, R.E., was on board the fleet to take command of any of the British forces engaged on shore.

There was a delay of several days in the arrival of the vessels with the French artillery and sappers; their guns and stores were also on board these vessels, so that nothing could be done in the way of active operations until they arrived; the intervening period was passed by the Admirals and Generals in making reconnaissances of the enemy's works from steamers, and determining upon the nature of the operations; this having been agreed upon, the following was the plan to be carried out. The French troops under General Baraguay d'Hilliers were to land to the westward of Bomarsund, near Tranvick, and move forward on the Castleholm Road to Finby, detaching a column to dislodge the enemy's troops, which were understood to have entrenched themselves in that village; while these movements were taking place, General Jones with a detachment of Royal Sappers and Miners, Royal Marine Artillery, Royal Marines and Seamen, with four field-pieces and rockets, together with two battalions of "Infanterie de la Marine Française," were to land to the north, move forward through the woods and form a junction with General Baraguay d'Hilliers' troops at Finby.

On the 6th of August General Jones went on board the "Reine Hortense," where all the generals and colonels of the French corps were assembled to receive their instructions, in respect to the disembarkation and advance. General Baraguay d'Hilliers explained in a very clear manner what each column was expected to perform, and to those officers who required it, more particular details were afforded.

August 7th.—After the men had dined on board their respective ships they were transferred to the steamers; those for the western attack proceeded to Bomarsund Bay, and those for the north to the small bay which had been chosen as the most favourable spot for landing: the vessels reached their respective points of rendezvous late in the evening: the troops remained on board for the night. Rear Admiral Plumridge visited General Jones to make the necessary arrangements for landing the troops, and assisting in any way in which the officers and men under his command could be useful.

August 8th.—The troops destined to operate against Bomarsund, on the north side, consisted of—

ROYAL ENGINEERS AND ROYAL SAPPERS AND MINERS UNDER CAPTAIN KING, R.E.

Subalterns.	N. C. O.	Privates.	Buglers.	Total.
2	14	79	2	98

ROYAL MARINES UNDER MAJOR NOLLOTH, R.M.

Captains.	Subalterns.	N. C. O.	Privates.	Drummers.	Total.
9	18	39	586	7	659

NAVAL OFFICERS AND SEAMEN.

Lieutenants.	Mates.	Petty Officers.	Seamen.	Total.
3	4	5	95	107

in two portions; one under Lieutenant Burgess with four 12-pounder howitzers; the other under Lieutenant Cudlip, with a proportion of 24-pounder rockets, under the orders of Colonel Graham, R.M., with Captain Elliott, R.M., Brigade-Major.

"Infanterie de la Marine Française" under Colonel Fieron, 1,500 strong.

The whole commanded by Brigadier General Harry D. Jones, with Captain H. St. George Ord, R.E., Major of Brigade; Lieutenant J. C. Cowell, R.E. A.D.C.; Lieutenant Hon. E. Cochrane, R.N., A.D.C.

Officers of Royal Engineers { Captain F. W. King.
Lieutenant C. B. Nugent.
Lieutenant Hon. C. Wrottesley.

Captain Giffard, of H M's ship Leopard, having been appointed by Admiral Plumridge to superintend the disembarkation of the troops, and everything being ready by 2·30 A.M., the men were put into the boats and landed at 3 A.M. As soon as the troops were formed, according to the brigade orders annexed, the advance took place, and they moved along the high road to Bomarsund; after passing the village of Monkstettar the French troops were halted, and orders were given to Colonel Fieron to protect the rear of the column, and also to detach a strong party to observe the road from Saltwick, which joins the Bomarsund Road about half-a-mile in advance of the village; the column then moved forward until the advanced guard arrived in sight of the western tower (Tzee) when it halted, waiting for the detachment which General Baraguay d'Hilliers had agreed with General Jones should be sent to complete the communications of the two columns. Soon after the halt Colonel Ducrot, of the 3rd Regiment of the Line (French), reported his junction to General Jones, and the advanced posts were then established along the front of the enemy's works. The French troops were placed in position, and with their "tentes d'abri" were soon under cover; the British were halted in the wood on the reverse of the hill running parallel with the enemy's works, and were directed to hut themselves. An immediate reconnaissance of the ground in front of the enemy's works was then made. (See plate 4)

The British head-quarters were established a quarter of a mile in rear of their camp, and those of the French in the village of Finby, south-west of Bomarsund, and distant about two and a-half miles.

The position of Bomarsund was of considerable extent, and was occupied by the Fort of Bomarsund, a large casemated work and three advanced circular towers, also casemated, on commanding points. The right tower, on the Island of Presto, was to defend the bay on the east, and to cross its fire with that from Nottick Tower upon the channel between Presto island and the main work. Nottick Tower was erected upon a bold headland, 130 feet above the sea; its position was a very important one, not alone for the defence of the numerous bays around it, and for protecting the channel between Presto and the main work; but also as forming one of the defensive works on the land front. It had a fine command of the ground on the right flank of the position as well as in front of the centre.

Tzee Tower was also upon an elevated piece of ground, 195 feet above the sea. This tower was intended to fire upon the approaches from the west, and the only carriage-road from the country to the principal works. As the advanced towers only formed part of a general plan, they did not flank each other on the land fronts, and afforded no mutual support.

The country is one mass of granite, with an extremely rough and uneven surface, in many parts large boulders cover the ground, and except bordering the road to Castleholm, little cultivation was to be found, the face of the country presenting nothing to the eye but one dense pine forest. As trenches could not be formed, it was necessary to make the parapets for the batteries and approaches with sand bags and gabions: fortunately both British and French were well provided with sand bags.

The outpost duty of the camp devolved upon the Royal Marines and Royal Marine Artillery, who furnished pickets of 150 men, which were pushed forward to the front of the large hill in front of the position, and placed in communication with the French left.

August 9th.—The British force paraded under arms at 2·30 A.M., on this and each succeeding morning, until the advance of the French rendered this precaution no longer necessary; the advanced sentries, pushed forward before daylight to feel the enemy, were withdrawn as the day broke, and when the fog, which was usually very dense, cleared away, the troops were dismissed to their usual duties. General Jones accompanied General Niel, of the French Engineers, to inspect the sites for his proposed batteries. General Jones visited General Baraguay d'Hilliers, General Niel was present, and they discussed the proposed plan of attack. A reconnaissance was made of the site of proposed battery.

Captain King, R.E. left camp at 3 A.M. to bring up stores to camp; they were put ashore from the transport Julia, at the landing place in the bay below the village of Monkstettar. Captain Lyons, interpreter, with one non-commissioned officer and three men, was employed in securing country carts and horses for their transport.

3 Non-commissioned officers,	12 Native drivers,
30 Privates,	24 Horses

were employed in this service, and the following stores were brought into camp:—

234 Pickaxes,	4 Crowbars,
94 Shovels,	20 Bill hooks,
4 Felling axes,	9 Hand saws,
6,000 Sand bags,	10 Hand carts,
1 Box smith's tools,	1 Forage cart.
17 Fascine chokers,	

During the day the enemy fired occasionally from Tzee Tower, and some of their shells burst over the British camp. A battalion of the French Infanterie de la Marine moved up as a support to the British camp.

August 10th. — A detachment of three non-commissioned officers and twenty privates, R.S. and M., under the command of Brigade-Major H. St. George Ord, R.E., left the camp at 3 A.M., for the transport "Julia," to select intrenching and other tools for the siege.

The party returned about 6 P.M. Six 32-pounders were landed from the men-of-war at Bomarsund, and three of them were brought to the camp, a distance of nearly four miles, on sledges*; 150 seamen were employed drawing each gun, of whom 100 were supplied by the ships, and fifty from the camp, and three officers and one surgeon were attached to the whole.

3 Non-commissioned officers,	16 Drivers (Natives)
20 Privates,	32 Horses, with carts,

were employed, and the following stores were brought into camp:—

50 Pickaxes,	20 Hand hatchets,
206 Shovels,	4 Hand-carts,
129 Bill hooks,	8 Fascine chokers,
2 Carpenter's tools (boxes)	6 Hand-barrows,
2 Miner's tools (boxes)	16 Crow-bars,
1 Smith's vice,	26 Gabion knives,
1 Grind stone,	10 Mallets,
3 Nails (boxes)	16 Cases of ammunition.

Lieutenant J. C. Cowell was severely wounded by the accidental discharge of a revolver about 9 P.M. A further reconnaissance was made.

General Jones attended at the French head-quarters, when the following proposed plan of attack was approved, and ordered to be carried out.

* These sledges were constructed by the Navy; they were 19 feet long by 3 feet wide, and were formed out of rough trees, connected by bolts and cross pieces, and secured by rope forming diagonal ties.—ED.

Proposed Plan of Attack.

The French to erect a battery for four mortars, and another for four 16-pounders, to destroy the roof of Tzee tower, in order to prevent the enemy from occupying it with riflemen; this accomplished, approaches to be made to the ridge in advance, which is about 300 yards from the tower; and on the crest of it a breaching battery to be thrown up for four 30-pounder French ship guns.

The British to build a battery for six 32-pounders on the heights to the left; these two batteries to open their fire at the same time upon Tzee tower. After the fall of the tower, approaches to be made towards the principal work, and batteries to be erected in favourable positions for breaching the rear of it, (one, if possible, on the Telegraph hill.) General Jones to take care that the left of the position be well watched, to prevent the possibility of any communication between the fortress and the country.

The enemy fired repeatedly during the day into the British and French camps.

The "Penelope" frigate got on shore in endeavouring to pass the islands of Presto and Tofto; after throwing guns overboard and losing some men she was got afloat without much damage. It having been reported that individuals were passing to and from the enemy's works, the pickets were pushed closer up to the latter.

August 11th.—Lieutenant J. C. Cowell was sent to the hospital ship.

The advanced sentries were pushed forward to cover the left of the French posts, which had taken up a position near the place, in order to be enabled to commence their batteries this night.

General Jones, accompanied by General Niel, inspected the site of the British battery.

The Brigadier General received a report from Admiral Plumridge that eighty Russians had landed on the north side of the island.

100 of the Infanterie de la Marine were sent to Finby to make gabions.

2 Non-commissioned officers, 6 Privates, R.S. and M.
1 Officer, 3 Non-commissioned officers, 100 Privates, R.M.

were employed filling sand bags. Numbers of bags filled 5,000.

1 Officer, 3 Non-commissioned officers, 60 Privates,

of this party were employed in the afternoon removing sand bags.

1 Non-commissioned officer, 8 Privates, R.S. and M.

were employed making fascines.—Number made 4.

Captain F. W. King, Lieutenant C. B. Nugent, Lieutenant Hon. C. Wrottesley, escorted by

2 Non-commissioned officers, 14 Privates, R.S. and M.

were employed reconnoitering, and examining ground, laying out road to the top of hill, &c. During the day the remainder of the company, off duty, were making huts and clearing camp.

At 9 P.M. Lieutenant Nugent, with an escort of ten sappers, left the camp to reconnoitre. The enemy opened a sharp fire from the fort at about 12 o'clock with grape, but no damage was done.

Three more 32-pounder guns were brought to the camp during the day by seamen and marines, under Captain Hewlett, R.N., H.M S. "Edinburgh," 200 men being attached to each gun.

6 Drivers (natives), and 12 Horses

were employed removing ammunition, &c.

August 12th.—The French commenced work last night, and continued unmolested until about 1 A.M , when a sharp musketry fire took place, accompanied by a fire of artillery from the tower, with occasional rounds of grape to scour the woods.

The night was most favourable, as the moon was almost entirely obscured by clouds.

Considerable progress was made with the formation of the road up the hill, by which the guns were to be taken to the battery.

Two Russians, found in the adjoining village, were made prisoners.

Captain Ramsay and Commander Preedy arrived to command the Seamen, who now amounted to 14 officers and 168 men.

1,500 round shot and shells were brought from the Fleet.

A reconnaissance was made by the Brigadier General to select the site for the breaching battery against Fort Tzee, and the spot chosen was the top of the Round Hill at 650 yards distance.

Captain King, R.E., having laid out the road by which the guns were to be brought into the battery,

5 Non-commissioned officers, 36 Privates, R.S. and M.

were employed upon it, and considerable progress was made.

2 Non-commissioned officers, 8 Privates, R.S. and M.

were employed making gun platforms.

4 Non-commissioned officers, 46 Privates, R.S. and M.

were employed making fascines, and 1 Non-commissioned officer reconnoitering.

4 Officers and 91 Seamen

were employed removing sand bags to the top of the hill, and depositing them in the neighbourhood of the battery, out of the view of the enemy. Several shots were fired from the fort during the day. A private of the Royal Marines was wounded by a splinter of a shell in the ankle. A sledge loaded with bullocks' hides and gun-carriages arrived at the camp at 1 P.M. Six gun platforms were made.

2 Non-commissioned officers, 30 privates

were employed in removing them to the neighbourhood of the battery. Eleven fascines were made and carried up to the battery.

6 Drivers (natives) and 13 Horses,

were employed removing ammunition from landing place to camp. 1,500 round shot were brought up.

August 13th.—The French opened their mortar and gun batteries at 4·30 A.M. Both batteries were formed with sand bags. The surface of the ground being rock, and no earth to be procured conveniently, sand bags were used to form the parapets.

A heavy fire of shot and shells from the enemy was kept up on the French batteries and British camp.

4 Non-commissioned officers, 45 Privates, R.S. and M.

were employed making fascines for the road.

1 Non-commissioned officer, 3 Privates, R.S. and M.

were employed erecting hospital tent.

1 Non-commissioned officer, 7 Privates, R.S. and M.

were employed making roads.

1 Non-commissioned officer, 2 Privates, R.S. and M.

were employed as escort to officers reconnoitering.

4 Officers, 102 Seamen

were employed removing ammunition to battery.

1 Officer, 4 Non-commissioned officers, 110 Privates, R.M., and 110 Infanterie de la Marine Française

were employed filling and removing sand bags to the battery.

A party of seamen, with two loads of bullocks' hides, arrived at the camp at 8 A.M. One of the French soldiers attached to the British force was wounded.

At 4 P.M. a white flag was hoisted on Tzee tower, the garrison asked for two hours to communicate with the governor but were refused, and one hour was allowed; the firing re-commenced at 6 P.M., when the white flag was again hoisted.

1 Captain, 1 Subaltern, 1 Sergeant, 24 Rank and file, R S and M.
with 1 Officer, 150 Rank and file, R.M.

under Brigade Major Ord, commenced the 5 gun battery against Tzee tower at 9 P.M.

August 14th.—During the night the French took possession of Tzee tower, making prisoners of the garrison.

A sharp fire was interchanged between the ships in harbour and the towers, between 12 and 1 o'clock this morning: several shots were fired from Nottick tower over the breaching battery, and at 3 A.M. they opened a sharp fire on it, but with little effect.

Four 32-pounder guns were taken up to the battery this morning by a party of seamen, under the command of Captain Ramsay, R.N., of H.M.S. "Hogue."

The battery against Fort Tzee being now no longer required, the Brigadier General approved of its being turned against Nottick. Sites for howitzer batteries were also chosen in the neighbourhood of it to shell the fort from.

A private of the Royal Marines was killed, whilst lying in his tent in camp, by a round shot.

At 6 P.M. Lieutenant Nugent, R.E., with

1 Non-commissioned officer, 10 Privates, R.S. and M.

began removing sand bags from the right of the battery, and laying them in the new position, and at 8 P. M. Brigade Major H. St. G. Ord with Lieutenant Hon. C. Wrottesley, and

4 Non-commissioned officers with 25 Privates

relieved them and continued the work.

1 Non-commissioned officer, 6 Privates (carpenters), R.S. and M.

were also employed preparing and laying platforms.

A working party of 3 Non-commissioned officers, 20 Privates, R.S. and M. under Captain King and Lieutenant Nugent, came into the battery at 12 o'clock: but no relief took place till 4 A.M., when the battery was completed for three guns, with a splinter proof magazine, and was handed over to Captain Ramsay, R.N., and the seamen of the brigade, by whom it was armed with three 32-pounder guns of 42 cwt. each, and at 8 A.M. fire was opened against the fort.

1 Officer, 100 Rank and file, R.M.

were employed carrying sand bags during the night, and were relieved by a similar number at 1 A.M.

The seamen who arrived at midnight to arm the battery also assisted in carrying sand bags until required for their other duty.

The working parties were much impeded during the night by the fire from Nottick and Presto, and by some shells thrown from the mortars in the main work.

The French out-posts were considerably advanced during the night, and possessed themselves of Telegraph Hill.

The exterior of Tzee tower was found much battered; the 16-pounder shot having produced considerable effect upon the granite.

A report having been received that 200 Russians were advancing from the north, the Brigadier General ordered 100 Marines from camp to reinforce the French detachment in the rear of the British camp.

Description of the Battery.

The breaching battery against Nottick tower was constructed of sand bags, for three guns, being 32 pounder (42 cwt.) guns mounted upon ship carriages, and worked on wooden platforms.

The thickness of the parapet of the battery was fifteen feet, having its interior crest seven feet high, with the embrasures at central distances of fifteen feet. The right flank of the battery was protected by an epaulment forty feet long, (which was a portion of the parapet of the battery erected previously, and intended to be directed against Tzee tower). In constructing the parapet the interior and exterior were carefully laid in regular courses, of headers and stretchers, regardless of the embrasure openings, and after the interior, exterior and ends were securely built, the interior was filled in with sand bags, the embrasures being formed last by taking out the necessary number of sand bags, leaving, however, the outer portion as a screen until the battery was armed and ready to open fire; at first the cheeks were revetted at the neck with gabions, and the soles of the embrasures covered with dried bullocks' hides; but both these precautions were dispensed with latterly, there being no musketry fire to contend against; the remainder of the embrasures were built with sand bags: after all the embrasures had been completed, and when the guns were ready to open their fire, the sand bags forming the exterior screen were thrown outwards, and left at the foot of each embrasure.

The battery was provided with one magazine, which was constructed behind a convenient ridge of rock, a short distance in rear of the left gun. It was of the plan and section shown in the accompanying drawing*, having an entrance at the higher end, the other being blocked up with sand bags.

A good supply of planking ten inches wide and two inches thick, and some joists and rafters about four inches square, were found stacked at the foot of the hill on which the battery was placed, and these were used in the construction of the magazine and platforms. For the magazine, planks about fifteen feet long were laid in two tiers, breaking joint, sloping against the vertical face of the rock, and well covered with sand bags; one end of the cavity thus formed was closed with planks and bags, and the other left for an entrance. The platforms consisted of twenty of these planks laid upon eight of the joists as sleepers, they were fifteen feet long, by ten feet six inches broad, and the ground in rear of the embrasures being very hollow, the space was filled up with sand bags to reach the required level, and sand was then spread over it, upon which the sleepers were laid. To secure the planks, two joists, as ribbands, were spiked down over the outer edges of each platform.

August 15th.—The breaching battery† opened fire this morning at 8 A M., with good effect; the guns were manned by seamen under the command of Captain Ramsay, R.N.; four 12-pounder howitzers, which were placed in position to the left, under Lieutenant Burgess, R N., also opened at the same time.

At 10·30 a round shot came in through the centre embrazure, striking first the trunnion of the gun, and afterwards Lieutenant the Hon. C. Wrottesley, R.E., who was in charge of the working parties. Lieutenant Wrottesley died within four hours.

Tzee tower, which had been set fire to during the night by a shell from a mortar in the main work, blew up about 11 A.M.

A 10 inch gun was landed from H.M.S. "Blenheim" to the south of the main fort.

* This is omitted, the section of the magazine being similar to the common triangular one.—Ed.

† This battery fired 487 shot and 45 shells in 8 hours.

At 3 P.M. the walls of the tower were completely beaten down, though the enemy's gunners had shown great bravery in their endeavours to clear the embrasures.

At 4 P.M. the seamen in the battery were relieved by the Royal Marine Artillery, and shortly after the fort ceased firing, a practicable breach having been formed in the four embrasures facing the battery.

At 5 P.M., a white flag was hoisted upon Nottick tower, and upon this being reported to the Brigadier-General, Brigade Major Ord was ordered to take immediate possession of it. This he proceeded to do at 6 P.M., having with him

5 Royal Sappers and Miners, and
3 Lieutenants, 100 Rank and file, R M.

under Captain Elliott, and after a very difficult march over the rocks, arrived at the fort, which he found to contain a garrison of

1 Captain, 1 Lieutenant, Finnish Rifles,
1 Lieutenant of Engineers,
125 soldiers, of whom 5 were killed, and 8 wounded.

The prisoners were disarmed, and placed for security in the roof of the tower, and a strict reconnaissance was made of the fort and its neighbourhood, the position of which was found to present great difficulties in keeping up the communication with the Brigadier-general, and having been reinforced during the night by a party of Marines under Colonel Graham, R.M., the prisoners were accordingly brought away about 4 A.M. to camp.

August 16th —At about 10 A.M. the blockships opened their fire upon the main work, in conjunction with the French mortar and howitzer batteries, and the French Chasseurs kept up a very sharp fire upon the embrasures of the gorge work.

The Brigadier made a reconnaissance for the establishment of a battery against the Main fort, and selected a site upon the top of the Telegraph Hill for howitzers and rockets.

The French breaching battery against Bomarsund was considerably advanced, and was to have opened fire at daylight on the 17th, but about noon a flag of truce was hung out, and the garrison under General Bodisco surrendered unconditionally.

Two thousand prisoners laid down their arms and marched out to the pier, where they were at once embarked in the Men-of-war lying in the harbour.

List of Engineer Stores Expended during the Siege of Bomarsund, between the 8th and 20th August, 1854.

Tracing lines	4	Spun yarn — lbs.	50
Carpenter's hammers	3	Tenon saws	2
Glue brushes, and pots	2	Measuring tapes, (50 feet)	3
Hand axes	10	Gimlets	6
Gabion knives	8	Steel bladed squares	2
Handsaws	7	Nails of sorts — lbs.	50
Rules, (2 feet)	4	Screws, 3 inch — dozen	4
Shovels	14	Handsaw files	10
Pickaxes	10	Short crowbars	3
Fascine mallets	1	Hambro lines	2
Billhooks	14	Broad axes	7
Felling axes	8	Baskets (bushel)	3
Pickaxe helves	15	Camp kettles	1
Sand bags	1,307	Hand carts	1

N.B.—With more care and attention on the part of the person in charge of the stores, the expenditure would not have been so great.

Brigade Order.

1. The troops to be employed under the orders of Brigadier General Jones consist of 1 company Royal Sappers and Miners, Captain King, R.E., 90. 1 battalion Royal Marines, Colonel Graham, 620. 4 Field-pieces. 1 detachment. 2 24-Pounder rocket tubes.

2. The troops will land with three days' provisions cooked, and in light marching order.

3. On landing they will be formed as follows :—

Advanced Guard.

20 Royal Sappers and Miners, 100 Royal Marines.

Support.

50 Royal Marines. Detachment with one rocket tube.

Main Body.

400 Royal Marines, 50 Royal Sappers and Miners. Detachment with one rocket tube. 20 Royal Sappers and Miners, 4 Field-pieces, 70 Royal Marines, 2 French battalions, 1,500 strong each, who will receive orders from the Brigadier General on landing.

4. Colonel Graham, Royal Marines, assisted by Captain Elliott, Brigade Major, Royal Marines, is requested to take command of the column, and to select an intelligent officer to command the advanced guard. He will be accompanied by Captain King, Royal Engineers, who will afford him the benefit of his professional assistance.

Lieutenant Nugent, R.E., will be attached to the advanced guard, and Lieutenant the Hon. C. Wrottesley, R.E., to the Sappers of the main body.

5. Immediately after the advanced guard has landed, the officer commanding it will push into the woods from 400 to 500 yards, according to the nature of the country, taking care to keep himself in communication with the main body, and not to advance it to a greater distance without orders. On receiving the order to advance, he will do so in extended order in a direction parallel to the sea, and keeping a good look out on his right flank. As soon as the advanced guard discover the enemy, they will acquaint the officer in command of the column, and will at the same time continue to advance steadily, driving the enemy before them. The distance of the support from the advanced guard will be regulated by the character of the ground. Care must be taken that a good communication is kept up between them, the advance, and the main body, and that they are prepared to move up at a moment's notice. Colonel Graham will throw out such flanking parties as may be necessary to observe and cover his flanks. Should an enemy be discovered, the brigadier is to receive immediate notice of the direction in which they may have been seen, and their apparent strength.

The field artillery will follow the main body as closely as circumstances will permit, and will be held in readiness to act promptly on any order they may receive from the brigadier, or officer in command of the column.

The rockets will not open fire excepting by direction of the brigadier or officer commanding the column.

OBSERVATIONS.

The position of Bomarsund, including the advanced works, had been closely reconnoitered from the sea, from every point where it was prudent to approach; but so varied were the features and so different was their appearance, according to the points from which they were seen, that it became impossible to fix with anything like certainty their respective distances, and not being able, from any point to which our reconnaissances had extended, to obtain a view of the ground forming the front of the position, nothing definite could be determined as regarded the precise nature of the attack. until after the place should be invested.

It was evident that the first object was to obtain possession of the two advanced towers on the land front, and to throw a body of troops into the woods on the island of Presto, so as to shut in, as much as possible, the garrison of the principal work.

It was expected that a vigorous defence would be made, as a few days previous to the landing of the troops, every public building and private house within range of the guns of the towers was set on fire and destroyed, including even the fine military hospital on the island of Presto.

Immediately after the troops were placed in position and the outposts established, General Niel reconnoitered the ground from the sea on the right, and in front of the French position, and General Jones that to the sea on the left. Each made a report to General Baraguay D'Hilliers, who approved of the mode of attack proposed by the Generals, and directions were given to proceed with the work allotted to each column.

The principal operations necessarily devolved upon the French troops, who, from their number and equipment, were enabled to undertake and perform works which the force under General Jones's command could not attempt, from the smallness of its number and the different descriptions of troops of which it was composed.

The French pushed on their works with vigour, notwithstanding that the enemy kept up a sharp fire upon their workmen. Their front was well protected by their light troops, who were ever ready and vigilant, and did good service by the accuracy of their fire; they were armed with the carabine-à-tige.

The reconnaissance was extremely difficult; the ground being very rocky and uneven, and partially covered with pine trees, it was necessary to scramble over the rocks, and obtain cover from the enemy's sight in the foliage of the trees. This was a service of danger and not of easy attainment, as in the reconnaissance it was necessary to examine well the intervening ground along the entire front, in order to take advantage of every feature which could facilitate the establishment of batteries in the most favourable positions, and also, as far as practicable, to acquire a knowledge of the ground between the towers and the principal work, it being desirable to determine, if possible, the number and nature of the works to be thrown up for the reduction of the principal work, after the advanced towers should be captured.

Objections may be made to the great distance of the battery from the object to be breached; this was unavoidable—on account of the features of the ground the battery was placed upon the crest of the ridge, running parallel with the enemy's position; the ground falling rapidly to the bottom of the valley in the direction of Nottick tower as far as the sea, and rising again from the opposite side of a small bay. From the surface of the ground being bare rock, it became necessary to form all the parapets, both for approaches and batteries, with sand bags, filled where sand could be found.

The French were fortunate in finding sand in a very convenient situation, close to their approach and first batteries. The British found sand in the valley adjoining their camp, from whence the sand bags were carried at a great cost in labour and time, up the steep face of the hill, to the site of the breaching battery. In these siege operations sand bags proved of the greatest use; in fact, it would not have been possible to have established the batteries without them. By the use of them cover was soon obtained against musketry fire, and when made of proper thickness they made an excellent parapet. In such cases the embrasures should be revetted with gabions, and where practicable the soles of the embrasures should be covered with bullock's hides.

The gabions made by the French were of larger diameter and stouter make than those in the British service: had they not been so strong they would not have stood the work required of them.

The expenditure of sand bags was, as is usually the case, very considerable, and that they made an efficient parapet is shown by the fact that 38 cannon shot were found in the parapet, when the battery was dismantled.

The British not having any platforms with their siege equipment, made those required from timber found close to their camp, consisting of slight joists about four inches square, and planks 10 in. wide by 2 in. thick, of different lengths; the sleepers were formed with these slight joists, laid upon sand bags, and the planks were secured with ribbands, nailed to the outside sleepers. These platforms were not strong enough, and required frequent repairs throughout the day.

The practice with the 32-pounders was excellent, and they appear to be admirably adapted for breaching.

The Sappers, although not required to sap, proved themselves extremely useful and intelligent, and worked hard in the formation of the battery.

The Royal Marines, who had to perform the outpost duty, distinguished themselves in one most important particular—vigilance. The officers were very attentive to the duties required of them.

It would prove of great advantage if the corps of Royal Marines were thoroughly drilled as light infantry.

Engineers.

The duty of the Officers of Engineers was very severe, from the small number of them, (one captain and two subalterns). There should always be one captain and three lieutenants with each company of Sappers, so that a regular relief can be established, and the captain take the direction of any work that may be ordered. In the event of a casualty, the captain will be able to take his tour of duty, so as to keep the roster for the other officers undisturbed. In all expeditions one officer of Engineers should be sent out for the special duty of making the surveys and plans that may be required. On the present occasion very great inconvenience was experienced from the want of such a disposable officer.

Artillery.

The battering guns were procured from the men-of-war. Six 32-pounders (42 cwt.) were landed and dragged to the camp, by seamen, to a distance of upwards of three miles, upon wooden sledges, constructed according to a plan proposed by Lieutenant Murray Aynesly, R.N., of H.M.S. "Hogue." They answered very well, but are susceptible of improvement, by applying small iron rollers or wheels to them. The labour of lifting and placing the wooden rollers under the sledges was very great, and very trying to the men. This was a work of great labour, requiring a large number of men : two days were required for bringing up six guns. The shot and small stores were brought in cars of the country, which came forward in great numbers as soon as confidence was established. The price paid per diem was 4s. for each pair of horses, with a car and driver. Without the assistance derived from these cars the operations must have been considerably retarded.

The French had great advantages in having horses and waggons belonging to their artillery and engineers, which they brought with them from France, and which they employed in transporting their guns and stores to their approaches, whereas the British had to do everything by manual labour ; from the depot at their camp the ascent to the battery was over rough rocky ground, difficult enough for an individual even unencumbered with a load on his back, and it is highly to the credit of all employed on this duty, that it was willingly and cheerfully performed.

In closing these observations, it would be very unjust towards the French troops under the command of Colonel Fieron, attached to General Jones's column, Chef de Battalion Guicebert, and all the officers and men of the Battalions d'Infanterie de la Marine, if mention was not made of the zealous manner in which they executed every duty required of them, whether in assisting to carry up the stores to the battery or in their outpost duties, showing at all times an anxious desire strictly to carry out the Brigadier General's orders.

The weather during the operations was dry, but extremely hot during the day; at night the dew was very heavy.

(Signed) HARRY D. JONES,
Brigadier General Commanding.

H.M.S. Duke of Wellington,
Nargen Roads, 25th Sept. 1854.

DESCRIPTION OF THE WORKS AT BOMARSUND.

The figure of the principal work was that of a semi-ellipse, whose conjugate diameter was 1,000 feet, and the transverse 640 feet (see Plate 2); the front towards the sea was divided into a series of casemates, in two floors, with embrasures for artillery ; those fronting the Bay were used as a battery, and had heavy guns mounted in them,—those in the flanks were used as powder magazines, barracks, and store rooms, and some of the latter during the operations had guns placed in them—the openings for the windows were blocked up with brick. The gorge was closed by two buildings, used as quarters for the governor and officers of the garrison. Between these buildings was a large work of horse-shoe form, having two floors, casemated and armed with heavy artillery, to bring a flanking fire upon the approaches to the fort from the land side ; there were four entrances to the fort on this side, and loopholed walls at each side of them completed the enclosure.

The casemates, deducting the space for the guns, would accommodate 2,000 men, calculated upon the same data as for an English barrack, but, if necessary, a greater number could be lodged in them for a short period without much inconvenience—as many as 2,500 men.

Materials.

The materials with which the fort was built consisted of granite and bricks, the former found upon the Island, and the latter sent from Russia or Finland. The mortar was exceedingly bad, possessing scarcely any adhesive qualities.

Construction.

The geological formation of the island is granite; the foundation was the bare rock, and upon this the superstructure was raised.

When the interior of the work was laid open after its demolition, and an examination made of those parts which had not been thrown down, it appeared that the execution of the work was most defective; there did not appear to be any bond of the different parts one with another; for instance, the front and rear walls had no tie or connection with the piers and arches, apparently the latter were first erected, and then closed by the front and rear walls, which were carried up independent of the piers and arches, flush with them.

The upper arches were covered with about 6 feet of sand; over this was a timber roof, covered with plates of sheet iron, as a protection to the building from snow in winter.

The exterior walls of the sea front and of the circular battery in the gorge were built with heavy blocks of granite, averaging 3 ft. by 2 ft. 6 in. by 1 ft. 10 in. cut into a polygonal form (see Plate 1), generally hexagonal, with beds and joints of about 10 inches; and the back was of ashlar, if it can be so called when round or rough as when taken from the surface of the ground, which appeared to be the case with the major part of it.

The body of the work was divided into casemates—length 53 ft. 4 in., breadth 21 in front, and 19 ft. 8 in. in rear, height 13 ft. 3 in., with piers, 4 ft. 9 in. thick, between each room, having an opening of 10 feet as a passage to communicate from room to room, by which arrangement there was the power of circulating throughout the whole of the fort under cover.

Openings for ventilation, and for carrying off the smoke from the guns, were made, 2 ft. 9 in. by 3 ft. 8 in. over every embrasure, and a loop-hole on each side of every gun (see Plate 1). In each casemate there were two windows looking into the interior of the work.

The officers' quarters were not bomb-broof, having an ordinary trussed roof covered with sheet iron; the rooms were of a good size and well lighted.

The interior of the fort was entirely free from buildings, with the exception of a soldier's privy.

The communications to the upper floors of the casemates were by staircases inside, and also by a number of masonry ramps, running directly up to the level of the upper floor from the interior of the fort.

Supply of water.

This came from a well inside the fort, and from numerous others at a short distance outside.

Magazines.

The principal were in six casemates; three at the eastern end of the fort, and smaller ones near the entrances, by the ramps.

OBSERVATIONS.

From what has been stated as to the mode in which the walls of the fort had been constructed, it was evident that the granite blocks formed a solid facing only, not having any band or connection whatever with the material forming the back of the revetment; and further, that the solidity of the casing was very much affected by the numerous embrasures made in it for the guns in the casemates (see Plate 1.); each opening being a weak point, and as it was necessary to silence the guns firing through them, the cheeks of the embrasures were soon very much shattered, and consequently, the arch which rested upon them losing its support, fell down, and all the heavy stones of the casing above the embrasure followed; the debris of such large materials tended very considerably to form a breach, and as the interior of the wall was built with brick and very bad mortar, it was easily battered down, laying open the interior of the casemates, and making a practicable breach; the destruction of the outer casing was materially assisted by the firing of the guns in the casemates, when at an elevation; the explosion of the charge had the effect of forcing out the arch-stones,—this, combined with the concussion from without by the shot from the breaching battery, caused the wall to give way after seven or eight hours' firing. On those parts of the revetment where there was not an embrasure, the effect of a shot striking one of the blocks was merely to make a slight indentation on the face of the stone, satisfactorily showing that if the exterior and interior of the wall had been built entirely with granite, well bonded, and not pierced with embrasures, to have battered down such a wall would have been the work of time, with a great consumption of ammunition; to calculate the time would be impossible—the elements of calculation would be the distance, number of guns, weight of shot, and the quality of the granite, as well as the manner in which the wall had been built; and this latter would be difficult of attainment.

It may be considered that the result of the operations at Bomarsund did not prove the facility of breaching a granite wall, but showed simply the bad construction of the walls, and not the destruction of the material: it will be well that all officers bear this in mind, or otherwise they may be induced to underrate the powers of resistance of a granite wall, and thereby fail in any attack they may make by trying to breach such walls at long ranges, without allowing sufficient time to accomplish it.

The effect of the shot from the 10-inch guns of H.M.S. "Leopard" and "Hecla," was strongly marked on the walls of Presto tower, and was much greater than that of the 32-Pounders on Nottick tower, at a much shorter range.

Works similar to those at Bomarsund, presenting two and three tiers of casemates, have a very formidable appearance when seen from a distance, and generally a report is made of the number of guns. counting a gun for each embrasure; but overlooking one very important point, which is, the number of guns which can fire at one time upon a ship at 1,000 or 1,500 yards; at Bomarsund it was observed that not more than six guns could be brought to bear upon a vessel at that distance, and that number only by traversing some of the guns to the utmost extent the splay of the embrasures would permit. An officer when reconnoitering works should not overlook such an important point, as the power of annoyance or destruction at any given distance depends entirely upon the number of guns that can be brought to bear upon that point.

At Bomarsund the embrasures were so constructed that long ranges could not be attained, from the impossiblity of elevating the guns sufficiently, in consequence of the small height of the arches of the embrasures.

To obviate this defect in Presto tower, guns had been mounted upon the upper part of the roof, so as to enable them to fire into the Bay to the eastward of Bomarsund.

The windows in Nottick and the other towers which opened into the court yard were almost entirely blocked up with bricks, leaving loop holes to fire into the interior of the work, and a strong wooden tambour with loop holes had been erected inside to protect the entrance into the tower. (See Plate 3).

(Signed) HARRY D. JONES,
Brigadier General.

OBSERVATIONS BY BRIGADIER GENERAL HARRY D. JONES,

Recommending the Undermentioned Points for Consideration, when Erecting Works of Defence against Shipping, &c.

1.—Revetments to be covered as high up as practicable.

2.—Guns to fire "en barbette" when placed in situations not exposed to grape or musketry; parapets to be of earth.

3.—The Artillery to be placed in detached positions, and not concentrated.

4.—Guns to be placed so as to be able to fire upon the enemy's ships before they can take up their positions for battering the works.

5.—The ditches to be defended by a flanking fire, by musketry from loop holes in the counterscarp, or direct from loop holes in the escarp wall.

6.—Endeavour, if possible, to have an escarp 15 feet high, covered by the glacis, and then a berm of sufficient breadth to receive the ruins of the wall when battered and breached, without falling into the ditch; upon this berm guns might be mounted, if considered desirable.

7.—All works should be made as strong as possible on every side; an attack may be made upon the land fronts, as well as upon those facing the sea, though it could scarcely have been conceived possible that a battery of 32 pounder guns would ever have been constructed on the rocky height 224 feet above the level of the sea, where the British battery was established against Nottick tower at Bomarsund.

The advantages of revetments "en décharge" have long been acknowledged, and at Nottick tower were clearly demonstrated: when the casemates were laid open by the fire of our Artillery, the roof over them remained undisturbed, and had guns been mounted on the top of the tower, they might still have been used, notwithstanding the breach below. Had the towers been constructed with casemates having the exterior ends closed with earth, or by a thin wall to cover the ends of the casemates, no breach could have been made: the revetment wall would have been thrown down, but no opening into the casemates could have been effected.

All the guns in Nottick tower, which were exposed to the fire of the British battery, were principally disabled by the deflection of the shot from the cheeks of the embrasures wounding the carriages; thereby proving, as all former experience had shown, that it is very objectionable to place guns to fire through casemated embrasures.

With respect to the firing of the "Edinburgh," against the walls of the fort at Bomarsund, little need be said, as nothing really practical could be deduced from it; in the first place, every movement of the ship was made without molestation of any sort; the weather was extremely propitious and calm, and no sea was running. It must also be observed that it required 24 minutes after dropping her anchor at the 500 yards range before she was in a position to commence firing: the effect produced was what might be expected, when the fire of a broadside could be concentrated upon a wall at such a short distance.

To prevent the possibility of a ship overpowering by her own fire the defences thrown up for the safety of any anchorage or harbour, the artillery must be distributed in detached works, so that the broadside of a ship can never embrace them all, in any one position she may be placed in.

(Signed) HARRY D. JONES,
Brigadier General.

The following despatch, written by Rear Admiral Chads, is inserted here as a record of the zeal and energy shown by the Navy at Bomarsund —Ed.

"Edinburgh, off Bomarsund, August 12, 1854.

"Sir,

"In obedience to your directions to give every aid from the four ships of my squadron named in the margin* to Brigadier General Jones, to form a breaching battery, I consulted with that officer, who proposed to compose his battery of six 32-pounders of 42 cwt., which guns you had forwarded in the Belleisle, when the following operations were undertaken. Each ship having previously prepared two sledges, after a pattern made by Captain Ramsay, for dragging the guns, four were landed on the morning of the 10th, to convey three guns and the carriages and gear, with 150 men to each sledge, under their respective senior lieutenants, the whole being under the command of Captain Hewlett, of my flag-ship, encouraged occasionally by their own captains. The situation selected for the battery was four and a-half miles distant from the landing-place, over execrable ground; the greater portion over steep rocky hills and ploughed fields. At five o'clock the boats left the ships, erected shears, landed the guns, and had them in the General's camp by 1 o'clock; the exertions and good-will of the officers and seamen created much astonishment in the encampment of the French troops, who cheered them in passing, and on some of the most difficult ascents went in voluntarily and most cheerfully to the drag ropes, and gave their assistance. On arriving in camp the men were much exhausted, and lay down to rest and prepare their dinners, when an order arrived that they were to embark immediately, as the Penelope was on shore under the fire of the enemy, and their ships might be required; the order was received with cheers, and, forgetting their dinners and fatigue, they rushed down to their boats in three-quarters of an hour by a short route, but close under the enemy's fire. On the next morning the same number of guns were landed; but on this occasion with 200 men from each ship, as the parties the previous evening were much fatigued. The guns were in the camp by 10·30. The bands of the ships attended the parties, and the whole march was one of triumph over difficulties that previously had been considered almost insurmountable. The spirits of the men were occasionally excited by a dropping shot

* Edinburgh—Donald McL. Mackenzie, Senior Lieutenant. Hogue—Thomas Davies (B) Senior Lieutenant. Blenheim—George H. Clarke, Senior Lieutenant. Ajax—Walter J. Pollard, Senior Lieutenant.

from the enemy. It is unnecessary for me to expatiate on the merits of Captain Hewlett, the officers, and seamen, in performing this arduous service, but only to express my admiration of their great zeal and perseverance, as from personal observation on the spot you will have formed your own judgment.

"I have, &c.,

"H. D. CHADS, Rear Admiral, &c."

"Vice-Admiral Sir Charles Napier, K C B., &c."

The following notes relative to the operations of the French at Bomarsund are extracted from the "*Journal des Armes Speciales*," *for November*, 1854 —Ed.

"During the night of the 11th of August the Sappers, assisted by 300 Infantry, constructed a mask formed of two rows of gabions, filled and covered with sand bags, so as to be proof against grape shot, in front of the site for the first battery; and during the whole of the 12th the artillery were employed in constructing the battery under cover of it, for four 16 pounders, and another for four mortars, a few yards lower, on its left.

"During the night of the 12th the two batteries were united by a communication, which was partly excavated; a similar one was formed in rear, and a lodgment for riflemen was constructed with sand bags, 250 mètres in advance of the battery. A little wooded hollow formed a communication with the latter, and served as a parallel.

"During the 13th the batteries fired 350 shot and 240 shells, in 14 hours, at the tower, whilst the riflemen fired constantly into the embrasures. Although the shot broke on striking the granite, the stones were cracked, the joints opened, and towards evening fissures could be seen at the angles of the embrasures by the aid of glasses.

"During the night of the 13th another battery was constructed with sand bags, at 300 mètres from the tower; and at 4 o'clock next morning, finding that the fire of the latter had almost ceased, the riflemen and sappers got into it by an embrasure, and made the Commandant, 2 officers, and 32 soldiers prisoners; the remainder, consisting of 140 men, having retired to the main work.

"During the 14th the sand bags and other materials were removed from the works no longer required, to the right, under cover of the rocks and of the large unfinished barracks.

"On the night of the 14th an approach was constructed with gabions and sand bags, 100 mètres long, towards the gorge of the Main work, taking care to defilade it from Nottick tower. The artillery also formed a battery for four mortars and two howitzers on a spot not seen from the Main work, and 800 mètres from it.

"On the 15th this battery opened its fire, and 2 field pieces of the new pattern, placed among the rocks at a distance of 700 to 800 mètres from the Main work, also fired at it, their position being changed after each round, whilst the riflemen fired constantly at the embrasures and windows in the roofs, from which the Finland riflemen kept up a very galling fire. A heavy fire was also kept up by the fleet against the Main work. The great range and accuracy of fire of a gun on board a steamer carrying Admiral Chads's flag, which threw solid shot of 80 lbs. weight, were especially remarked.

"In the evening Nottick tower, having been breached by the British battery, ceased firing and surrendered.

"The fire of this battery was as remarkable for its precision as for its rapidity.

"On the night of the 15th of August, as the reverse fire from Nottick tower had thus ceased, a breaching battery was commenced at 400 mètres from the gorge of the Main work, but it was not finished before the fortress surrendered."

PAPER II.

Notes on the Demolition of the Russian Works at Bomarsund effected by the French in 1854,

Consisting of Extracts from the "Journal des Sciences Militaires,"

Translated by Captain Bainbrigge, R.E.

The floors of the casemates of the Main Work were covered with "debris" of every description, amongst which were cartridges, caps, and many loaded shells. Powder was scattered everywhere, and was mixed with several thousand sacks of flour, which the Russians had made use of to form barricades for protection against the effect of shot and shells.

The most simple and most certain mode of destroying the buildings was to prepare a sufficient number of charges, and fire sets of them separately, so that if any should fail to explode, means could be adopted for ensuring ignition before proceeding with the remaining portions. But such successive explosions would have caused much inconvenience, in consequence of the great quantity of loaded shells which were scattered throughout the casemates, and which could not be carried away, over the loose powder spread about, without such precautions being taken as circumstances would not admit of: besides the wooden roof, which covered the casemates, might be set on fire by the first explosions, and the flames might thus extend towards those charges which had not been exploded. The General commanding also settled this point, by deciding that the distribution of flour to the inhabitants of the islands was to continue until the evening before the embarkation of the troops, so that only a few hours remained for the officers of Engineers to make their preparations.

It was therefore necessary to explode all the charges at the same time, and to do this they required to be connected at a single point, which would take 2,000 mètres of hose. But there was no hose, and there were only 400 mètres of "cordeau porte-feu." The work of making hose was immediately commenced, but it was difficult to do this with the inferior canvass found in the fort, and with soldiers who had had no practice in this operation. It was desirable to employ the hose in the casemates, so that it might be protected from the effects of the weather and of the explosions, and to use the "cordeau," the ignition of which is almost instantaneous, in the court at the last moment. It was known that this mode of firing charges was liable to failure, and that it was prudent to double the "cordeau;" but there was not time to take this precaution, which would have saved much risk to those employed.

Great difficulty was experienced in determining the number and positions of the charges. There existed only very uncertain data as to the resistance offered by large masses of masonry, connected together throughout so great an extent, and consisting of two tiers of casemates; the large openings formed in the centres of the piers, to afford a communication throughout the building, must allow of the escape of gas produced by the explosion, and thus lessen its effect; and lastly, as both the time and the means of ignition were limited, it was necessary to avoid multiplying the charges too much, which would have prevented the work being finished before the embarkation of the troops, and likewise to take care that there were not too few charges, which would have prevented the destruction being complete.

In consequence of these considerations the following system was adopted:—

1st. At Presto tower, which remained quite intact, the destruction of which was to take place first, in the sight of both armies, and of which the complete demolition was desired, 6,600 lbs. of powder found there were distributed in six charges *a, b, c, d, e, f,* as shewn in Plate 3. The powder was contained in cartridges, which were merely piled on the floors of the casemates, the openings of which were previously solidly closed. The six pieces of hose, of equal length, intended to ignite the charges, were all connected with a heap of powder formed at *x* in the middle of the court, and a portion of "cordeau" (*g x*) enabled the explosion to be effected from the exterior. A large pile of wood (F) was also formed in the court, and placed in communication with the heap of powder (*x*) by means of a portion of hose. The object of this pile of wood was to produce such a fire as would, if necessary, destroy the tower, and ignite the charges which might not explode. The explosion took place at 4 P.M. on the 30th of August; the tower was lifted majestically, and when the smoke cleared away, nothing was seen in its place but a heap of ruins. The soldiers were struck by this fine spectacle, and loudly testified their admiration; and it deserved the approbation of miners, for the five charges exploded so well that not a single splinter was projected to a distance, and scarcely any large stones lay 60 mètres from the tower.

2nd. For the Northern tower, 3,740 lbs. of powder, divided into five charges, were used. The powder, which had been provided for the service of the French artillery, was contained in barrels of 220 lbs. and 110 lbs. each; these barrels were broken open at the top, and placed close together in the centres of the casemates. Excepting this difference, and the omission of the small charge *f*, the same arrangements as those at Presto tower were adopted. The explosion took place at 9 A.M. on the 31st August. Its effect was apparently not so satisfactory as that of Presto tower, some portions of the wall remaining standing, especially around the breach made by the British artillery, where two casemates still existed; but these were much shaken, and the fire completed their destruction.

The demolition was sufficiently complete to render it impossible to reconstruct the building, which was the object intended to be attained, but the quantity of powder employed must be considered as a minimum.

Nothing need be said about the Western tower, which had been much injured by our shot, and the destruction of which had been nearly completed by the Russian shells having set fire to the gunpowder which it contained.

3rd. For the Main Work nothing was provided besides the system of charges shown in Plate 2, Captain Barrabé was charged with the execution of the important duty of destroying it, and this presented difficulties of every description, for the mines were loaded and the hose was laid without interrupting the constant movements of the peasantry, amongst whom the sacks of flour were distributed, and who took advantage of the opportunity to carry off a number of other things.

The following is the manner in which the charges were arranged: - The chambers, which were formed in the masonry, were generally 3¼ feet long, by 2½ feet high, and 2 feet wide. They were loaded almost entirely with Russian cartridges, and the entrances to them were closed by shields, 2½ feet square and 4 inches thick, formed of two thicknesses of plank, which were solidly secured by means of logs, from 8 to 10 inches in diameter.

The main building was divided into five portions. To destroy the right extremity,* with which No. 1 staircase communicated, four charges were placed in the centre of the abutment wall of the casemate *a*; four others were established at the angles of the casemate *e* in the centres of the piers; and two barrels, containing 220 lbs. each, were also placed, side by side, upon the floors of the casemate, to assist in raising the arches, especially towards the outside. Those parts of the piers in the two adjacent casemates which were next to the charges were secured by means of shields and strong beams, and finally some barrels of powder were placed on the floors of the casemates *b* and *d*, as well as in the compartment *c*, which contained a great number of Russian loaded shells.

To blow up the corresponding portion at No. 2 staircase, barrels of powder were placed on the floors of the compartments *f* and *g*, and four charges were lodged in the casemate *h*, arranged as in casemate *e*; but no powder was placed in the centre of the casemate *h*, because it was intended to preserve the six casemates connected with No. 3 staircase, as they were required by the British, for the Fleet to make experiments in breaching them with shot and shells.

In the central portion, in casemate *i*, the same arrangements as those in the casemate *h* were made; and in casemate *l* the same as in casemate *e*; and the powder was placed in the compartments *j* and *k* in the same way as at the staircases Nos. 1 and 2. To destroy the corresponding portions at the staircases 5 and 6, barrels of powder were placed in the compartments *m*, *n*, *p*, and *q*, and the casemate *o* was prepared like casemates *e* and *l*.

Finally, in the casemates of the left extremity of the main work, charges were placed in the same manner as in that at No. 1 staircase.

4th. For the Horse-shoe work, as the piers were thin, and cut through near the ends, nothing was done except placing barrels of powder on the floors of the casemates *r*, *s*, *u*, *v*, *y*, and on those of the stores *t* and *x*.

As for the Officers' Barracks, a considerable quantity of wood having been employed in their construction, and their upper stories having been blinded with several tiers of strong beams, *fire* was had recourse to for their destruction; for this purpose preparations were made for firing them from F, F at each of their extremities. Nevertheless, in order to produce a large breach in each, and thus to ensure the destruction of their masonry, barrels of powder were placed in the store rooms, under the stairs at the centres of the barracks.

The arrangement of the charges above mentioned and of the hose is shewn in Plate 2. The hose rested everywhere upon lines of planks placed end to end. The quantity of "cordeau porte-feu" available was not sufficient to allow of all the trains being connected at one point; those of the right and centre of the main work were united at the point X, and those of the left of the main work and of the horse-shoe were united at Y. The charges in the latter were connected by means of five portions of hose, each 42 mètres long, united at Z, which was connected with the point Y.

Carcass composition and mealed powder were used to set fire to the wood piled at F, F, in the ground floors of the officers' barracks; ignition was to be effected by means of portions of hose, the ends of which were buried in the mealed powder, and

* See Table, page 24.

which were led through the windows. The ends of the hose united at X, Y, and Z were fixed in small boxes without lids, by means of grooves cut in the sides. These boxes were filled with mealed powder, and portions of "mèche anglaise*" 10 feet long were attached to them. Pieces of the same match, the use of which cannot be too much recommended, were fixed to the extremities of the hose for firing the officers' barracks. Care was taken also to spread some mealed powder over the numerous joinings of the hose.

All the arrangements above mentioned having been completed, on the 2nd September at 7 P.M., the time appointed by the General Commanding-in-Chief for the destruction of the Main work at Bomarsund, Captain Barrabé, who had gone through all their details with the greatest zeal, caused the mines to be fired by 5 non-commissioned officers of the company of sappers, and did not retire until he had assured himself that all the ends of the "mèche anglaise" were ignited. The troops of both nations, standing upon the surrounding heights, and upon the decks of the vessels anchored in the bay, as well as some of the inhabitants of the Aland Islands, awaited in silence, with their eyes fixed upon the fortress, the grand spectacle of its destruction. At the end of a few minutes, a series of nearly simultaneous explosions destroyed the greater part of the main work, as well as the centres of the two officers' barracks. An immense cloud of smoke, which was not dispersed for a long time, completely enveloped the fortress.

The fire burst out with great intensity in the two Officers' barracks; and the roofs of the Main work also took fire in several places. When the smoke dispersed, the results obtained could be better appreciated: the charges which had exploded had produced all the effect which was expected, but some of those in the Main work, and all those in the Horse-shoe work, had failed to ignite. During the night the fire extended, explosions of shells succeeded each other uninterruptedly, and all the rest of the charges in the Main work exploded, excepting probably one of those under No. 7 staircase; but the Horse-shoe work continued intact in the midst of the vast conflagration.

Although it was very dangerous to penetrate into the fort, Captain Barrabé offered to go and look for the ends of the hose leading to the five mines which had not exploded, in order to connect and fire them.

The General commanding the Engineers, who had already gone on board the Fulton, considering that so important a part of the fortress ought not to be left standing, accepted the proposition of Captain Barrabé, and sent to him, through Lieutenant Colonel Jourjon, an order to do all that was possible to blow up the Horse-shoe work. Not contenting himself with transmitting this order, Lieutenant Colonel Jourjon, who since the beginning of the siege had been foremost in all dangers, determined to join in the execution of it. These two officers, accompanied by Lieutenant Groult, Serjeant-Major Laflèche, and Serjeant Bergerolle, entered the Horse shoe work by an embrasure. At this moment the fire, which was extending through the ruins, reached the end casemate *y*, which contained a charge of 1,324 lbs. The box at Z was intact, the "cordeau" which united it with Y not having transmitted the fire: the five lengths of hose leading from Z had been disturbed by the explosions. The officers and non-commissioned officers who had entered hastened to take the "cordeau" out of the box Z, and to replace the five portions of hose leading to the Horse-shoe work. They could only find the two ends of the hose leading to the casemate *y*, the central part having been blown away, and then ignited by the explosions. The smoke which came out of the casemate *y* rendered it impos-

* This is probably Bickford's fuze.—ED.

sible to make any attempt to replace the hose in it. It was therefore necessary to rest satisfied with attaching a piece of "mèche anglaise" as quickly as possible to the extremities of each of the others, and igniting them. The explosion took place 5 minutes afterwards, but the charge at *u* was not ignited. That in the casemate *y* exploded an hour later, and that in the casemate *u* at about 1 o'clock, P.M.

It is difficult to give an exact account of the effects of the charges, as they could not be seen except from a considerable distance. The conflagration which extended to all parts of the fortress, the thick smoke which arose from it, and the shells which exploded at every instant rendered it impossible to approach the ruins; however by means of some hasty sketches the following results were noted:—

1. Main work. From the right extremity to No. 1 staircase, nothing remained standing excepting one pier nearly ruined. (See Plate 2). Between No. 1 staircase and the casemate *e* there remained one pier, which supported part of the exterior face containing two windows on each story. Between the casemate *e* and No. 2 staircase there remained likewise a part of the exterior wall, containing two embrasures on each story.. Between No. 2 staircase and the casemate *h*, one pier and a part of the exterior wall, containing an embrasure in each story, remained. The six casemates reserved for experiments by the British had been well preserved in the position intended. Between the casemate *i* and the staircase No. 4 nothing remained except a small portion of the front wall, corresponding to one of the piers. The same effect was produced between No. 4 and the casemate No. 7, as well as between that casemate and No. 5. A pier only remained between No. 5 and the casemate *o*, and the portion of front wall attached to it was rather larger than in the preceding cases. In the centre of the space between the casemate *o* and No. 6 staircase, three piers in succession remained standing, this is explained by the presence in these casemates of a great quantity of flour which almost completely filled the interior. Between No. 6 staircase and the casemate *e* there remained one casemate. The demolition of this part of the fort was rather less complete than that of the corresponding part on the right, and this was probably because the charge placed under No. 6 staircase was only 1,986 lbs., whilst that placed under No. 2 was 2,096 lbs. Again, near No. 7 staircase two casemates appeared to be intact, and probably one of the charges placed under this staircase did not explode. The four casemates at the end had entirely disappeared.

2. Horse-shoe work. At the time when Captain Barrabé embarked, the charge in casemate *u* had not exploded. One pier only remained standing between casemates *x* and *y*, besides the central portion of the building, which was to have been destroyed by the charge *a*.

3. Officers' Barracks. The charges placed under the staircases had made a large breach at the centre of each building; and as we left, the fire completed their destruction.

Finally, notwithstanding the uncertainty of the effects of mining in masonry, and the want of time and resources available, the object aimed at was fully attained. The six casemates required by the English remained standing, none of the fragments had been thrown so far as to strike either the troops or the ships in the harbour, and the fortress of Bomarsund now presents only a mass of ruins, impossible to rebuild; the stone is also exfoliated by the action of the fire, and rendered useless, for the granite of the Baltic has the remarkable property of decomposing and falling into dust when exposed to a high temperature.

The following Table shews the Weights of the Charges placed in the several Mines, reduced to English pounds, as well as the Lengths of the Hose, &c.

Titles of the Works.	Number of the Staircase.	Designation of the Room.	Number of charges. in the piers.	Number of charges. on the floor.	Number of lbs. in each charge.	Total in each casemate.	Total in each Work.	Length of Hose in yards.	Length of cordeau porte-feu in yards.
Main Work*	No. 1	*a*	2	—	275	880	24024	182	139
			2	—	165				
		b	—	1	1103	1103			
		c	—	1	662	1765			
		d	—	1	1103				
		e	4	—	275	1541			
			—	1	441				
	Nos. 2&3	*f*	—	1	772	2096		92	88
		g	—	1	1324				
		h	4	—	275	1100			
		i	4	—	275	1100			
	No. 4	*j*	—	1	772	2096		150	148
		k	—	1	1324				
		l	4	—	275	1541			
			—	1	441				
	Nos. 5&6	*m*	—	1	662	1986		134	137
		n	—	1	1324				
		o	4	—	275	1541			
			—	1	441				
		p	—	1	662	1986			
		q	—	1	1324				
	No. 7	*e′*	4	—	275	1541		183	139
			—	1	441				
		c′	—	1	662	1765			
		d′	—	1	1103				
		b′	—	1	1103	1103			
		a′	2	—	275	880			
			2	—	165				
Horse-shoe Work		*r*	—	1	1541	1541	8822	256	86
		s	—	1	1324	2096			
		t	—	1	772				
		u	—	1	1765	1765			
		v	—	1	1324	2096			
		x	—	1	772				
		y	—	1	1324	1324			
Officers' Barracks.		—	—	1	662	662	662	40	33
Ditto.		—	—	1	662	662	662	40	33
Presto Tower†		*a*	—	1	1765	1765	6617	165	27
		b	—	1	783	783			
		c	—	1	1268	1268			
		d	—	1	1268	1268			
		e	—	1	1268	1268			
		f	—	1	265	265			
Northern Tower‡		*a*	—	1	993	993	3750	143	27
		b	—	1	441	441			
		c	—	1	441	441			
		d	—	1	1103	1103			
		e	—	1	772	772			
Totals			32	38			44537	1385	857

* Six casemates adjoining No 3 Staircase were reserved for experiments.

† The powder was contained in 1300 cartridges, which were placed on the floor in heaps.

‡ The powder was in barrels, which were placed close together in the centres of the casemates.

PAPER III.

Report on the Demolition of the Russian Works at Bomarsund in September, 1854,

By BRIGADIER GENERAL H. D. JONES, Royal Engineers,

Accompanied by Extracts from the Journal of the Operations kept by Captain F. W. King, R.E.

Letter from Brigadier General Harry D. Jones, R.E., to the Inspector General of Fortifications, forwarding Reports upon the Demolition of the Works at Bomarsund in the Aland Islands.

Royal Engineer Establishment,
Brompton Barracks, Chatham, 8th December, 1854.

Sir,

I have the honor to forward herewith the Report of Captain King, Royal Engineers, who was appointed by me to destroy the unfinished buildings and batteries on the position in front of Bomarsund, and I also enclose a report made by Brigade Major Ord, who being employed on special duty inside the principal work, was enabled by observation and communication with the French Engineer officers to state generally the mode adopted by them for the demolition of the principal fort: from this it appears that no regular plan was pursued. In some of the casemates chambers were formed in the piers, and in others there were masses of powder laid upon the floor, in the centre of the room. From the state of the interior of the work, and the desire to hasten the demolition as much as possible, it was necessary for them to resort to such modes of proceeding as would be likely to lead to a successful result, and such was the case, although the entire of the walls were not thrown down; still every part (except that portion left for H.M.S. "Edinburgh," to make experiments upon) was so shaken that it would be necessary to take the whole down before a new fort could be erected.

The unfinished works at Bomarsund, ordered to be demolished, were in various stages of progress, the disposition of the whole being shown on the accompanying plan, No. 4. The building marked D was the most advanced, the walls being raised to a height in some places of 22 feet, and the scaffolding was all prepared for continuing the construction; whilst in several places in the other works, particularly in the round tower C, the foundations were only just raised above the ground; but in all cases were carefully covered with earth to protect them from the effects of the frost during the winter.

The plan proposed to be adopted was to place charges in the angles, and one in the middle of the length of each pier.

The first series of charges were fired to ascertain what would be the effect of the quantity of powder ordered to be used: the result was perfectly satisfactory, with the exception of the charge in the middle of the length of the pier; the effect of which was to make a large hole, and to shake the wall; it was therefore considered desirable to place two smaller charges, on account of the length of the pier; this plan was adopted and followed throughout with success. The entire of the operations occupied ten days, during which period the weather was generally stormy and unfavourable. The powder was brought on shore daily from H.M.S. "Ajax," (see Brigade Order), on board of which the company of Sappers and Miners had been embarked, there not being any accommodation on shore for them, and the weather was deemed too tempestuous and uncertain to justify me in placing the Sappers under canvass; and further, it having been reported to Admiral Sir C. Napier, commanding the Fleet, that the Russians had thrown some troops ashore on the northern side of the Island, to have left the company in camp at night might have risked their safety. During the operations of the day, pickets of Royal Marines from the men-of-war were posted well in advance, on commanding points, to give the alarm if any bodies of men should make their appearance.

The expenditure of powder was 134 barrels. Valuable assistance in destroying the foundations was afforded by parties of seamen from H.M.S. "Leopard" and "Ajax," ordered by, and under the personal direction of Rear Admiral Martin.

The tools used during the operations, which were brought out from Woolwich, were found to be of very good quality, and well adapted for the purposes to which they were applied: they consisted of felling, hand, and pick axes, crowbars 5 feet long, field service and miner's shovels, sledge and miner's hammers, saws, carpenter's and smith's tool-chests, &c. Short crow bars of about 3 feet long would, however, have been found very useful.

It is proper to state that the works and buildings on which Captain King was employed were those in process of erection, some having the foundations only laid in, some had the walls raised a few feet only, and others had the piers and front and rear walls raised to the springing of the arches. The ground in the immediate neighbourhood was covered with finely dressed granite for the ornamental parts of the building, and the ashlar for the embrasures of the casemates was all prepared ready for setting; these were all destroyed, by merely placing some of the wood of the scaffolding upon them and setting it on fire, which split the stones and rendered them useless: there were several sheds filled with slacked lime, and many thousands of bricks close to the buildings, ready for use. The bricks were broken to pieces, as far as time permitted.

Annexed are copies of the Brigade Order and Memorandum issued to Captain King for his guidance.

It is very gratifying for me to report that the company of Sappers and Miners distinguished themselves by their zeal, steadiness, and attention. I am happy to report that no casualty occurred during the operations, and that the demolition was most perfect. Captain King is deserving of great credit for the zeal and intelligence he displayed in conducting these operations; he was assisted by Lieutenant Nugent, R.E., and Lieutenant Durnford, R.M.A., who was acting as Assistant Engineer.

Accompanying this letter is a list of the plans and sketches to elucidate the report.

I have the honor to be,

SIR,

Your most obedient humble Servant,

HARRY D. JONES,

Brigadier General.

To the Inspector General of Fortifications,
&c., &c., &c.

ORDERS.

H.M.S. Ajax,

Bomarsund, 4th September, 1854.

1.--Captain King, with the 2nd Company Royal Sappers and Miners, will remain at Bomarsund to complete the demolition of the works finished and in progress, which remain undestroyed by the French force.

The necessary instructions, as to the mode in which this service is to be executed, have been already given by the Brigadier, and in carrying them out Captain King will be careful to act in conjunction with Captain Warden, H.M.S. "Ajax," to whom he will apply for such assistance, materials, powder, &c., as he may require, and with whom he will arrange as to the hours at which the men shall be sent on shore and embarked, as well as all the details of men, messing, &c., on board.

(Signed) H. St. G. ORD,
Major of Brigade.

MEMORANDUM.

Captain King, R.E. is charged with the demolition of the new buildings to the south of Bomarsund Fort. He will place the charges of powder in conformity with the plan which will be given to him, in which will be marked the positions of the several chambers. He will be at liberty to diminish the quantity of powder allotted to each charge, if he should find that the effect produced is greater than necessary.

As there will be great difficulty in finding proper or suitable materials for tamping, and as there is a great quantity of scaffolding poles, which can easily be cut to any required length, it is considered that the quickest and most secure mode of confining the powder, instead of tamping, will be to close the mouth of the chamber with pieces of the scaffolding poles made to fit tightly into the opening, and then to apply struts to the opposite sides of the gallery. Captain King is at liberty to adopt any other mode he may think preferable, bearing in mind that the work must be done as effectually as possible, and in the shortest space of time. An accurate record to be kept in full detail according to the following forms:—

No. 1.

Date.	Charge. No.	Where situated.	Quantity of Powder.	Nature of tamping or other mode adopted.	Effect.	Remarks.

No. 2.

Date.	Charge.	Number of N. C. O. and men.	Time in making the chamber.	Time employed tamping.	Remarks.

It is to be accompanied by such observations as Captain King may consider desirable.

The Report to be forwarded to the Brigadier General as soon after the operation is completed as can be conveniently done.

The entire company of Sappers is to be employed, and an application will be made for a working party from the Royal Marines.

(Signed) H. D. JONES,
Brigadier General.

Bomarsund, 1st September, 1854.

EXTRACTS FROM THE JOURNAL OF OPERATIONS CARRIED ON FOR THE DEMOLITION OF THE BUILDINGS AT BOMARSUND, BY THE 2ND COMPANY OF ROYAL SAPPERS AND MINERS, IN SEPTEMBER, 1854.

BY CAPTAIN F. W. KING, ROYAL ENGINEERS.

September 4th.—Operations were commenced at the building marked D. (Plate 1.) This consisted of 19 unfinished casemates, each 60 feet by 20 feet in the clear, (see Plate 3); the front wall, which was 6 feet thick, was faced with hexagonal blocks of granite about 2 feet deep, and was lined with brick, the interval being filled in with rubble masonry: the rear wall was 3 feet 6 inches thick, except in rear of casemates 9, 10, and 11, where it was 5 feet 4 inches thick; it was built of brick on a foundation of granite blocks, 5 feet to 6 feet thick: the pier walls were built of brick, 4 feet 9 inches thick, on a foundation of granite averaging 5 feet in thickness.

The front of each casemate was pierced with one embrasure and two loop-holes; the doorways in the rear wall were five in number, and the casemates which had no doorways had each two windows at the rear. There was also a doorway close to the front wall, connecting each casemate with the next. Adjoining No. 1 casemate were three small rooms, as shewn in Plate 3. The front walls were completed to a height of from 8 to 21 feet above the ground, the highest part being that adjoining Nos. 1, 2, and 3, casemates.

The height of the rear walls averaged 18 feet. The scaffold poles had all been left standing.

According to the orders of Brigadier General Jones, 6 chambers were formed in No. 2 room, as shewn in fig. 3, Plate 3.

Two Non-commissioned Officers and 18 Privates, Royal Sappers and Miners, commenced work at 8 A.M.; and at 11·30, A.M. the 6 chambers were ready. Powder arrived from H.M.S. "Ajax" at noon, the loading was immediately commenced, and by 2·55, P.M. the mines were ready for firing.

Pieces of three-quarter-inch powder hose, 13 feet long, were attached to the charges, and those of each opposite pair of mines were united in the centre of the room, each hose being laid in a channel of bricks, and having a length of portfire, calculated to burn two minutes, attached to it. A considerable quantity of bricks were used for the tamping, and short lengths of the scaffold poles were inserted and shored up, so as to render it as effectual as possible.

On the mines being fired, one pair exploded prematurely, owing probably to a defect in the portfire. The effect of the charges in the angles appeared satisfactory to Brigadier General Jones, who was present; but some portions of the pier walls being left standing, he desired that two charges of 60 lbs. each should be used in future for each.

Considerable difficulty was experienced at first in forming the chambers, owing to the quantity of scaffold poles and rubbish around, as well as to the want of short crow-bars, but they were all made as low down as possible, and generally under the centre of the foundation.

The remainder of the Sappers were employed clearing away rubbish and forming chambers in the other rooms of building D.

The number of men and the time occupied in the various operations are detailed in the accompanying return.

September 5th.—Work was commenced at 8 A.M., forming chambers in Building D, which were nearly completed by 7·30 P.M.

Great difficulty was constantly experienced from the scaffold poles being in the way of the workmen; these were however found very useful in assisting the proper tamping of the mines, by wedging in short pieces of the poles.

It being deemed desirable to destroy as soon as possible the portion of the Horse-shoe work which had been left intact by the French, a careful examination of it was made, and it was evident that any attempt to form chambers in the inside of it would be attended with extreme danger, the floors being covered with loose powder, in some places half-an-inch deep, whilst live shells were scattered in all directions; and both ends of the building were on fire.

It was supposed that the French had lodged a charge here, which for some reason had not exploded, but no trace of a chamber could be discovered, nor any tamping. Planks, of which a small number were found in the building, were laid down for the men to walk upon, and ten of the most experienced and careful miners were selected to place the powder.

Two charges, each of about 600 lbs., were placed on the floor, in the positions shewn in Plate 2 (*z*, *z*); they were well covered over with planks, &c., and heavy barrels of meal, which were at hand, were rolled close up to them; the intervening spaces were also filled with bricks, heavy stones and timber, and every thing which was at hand was heaped over. The powder-hose was laid along planks to the loopholes in rear, and enclosed in a channel formed of bricks, a piece of Bickford's fuze, 5 feet long, being attached to each of them on the outside.

The effect of these charges was very good, almost the whole of the upper story, (forming the chapel), and part of the roof being brought down, and a great portion of the rear wall was thrown down. Three or four shells were observed to burst towards the rear. In all the operations at this building no iron tools were allowed to be used, everything being done by the hand and by wooden handspikes. The powder, which had to be conveyed over the burning ruins, was carried in the ship's boxes, which were only unscrewed when it was wanted.

September 6th.—Work was commenced at 7·30 A.M. Two charges, each of 250 lbs., were lodged in the Horse shoe work, as shewn in Plate 2, (*w*, *w*,) advantage being taken of one of the spaces for the cooking boilers on one side, and of the oven on the other. The same precautions as before were observed, and the same mode of tamping was followed. These charges produced the desired effect: large portions of the piers were brought down, the remaining part of the upper story fell and filled up the lower story with rubbish, whilst the portions of wall left standing were so shaken as to render them perfectly useless, and were in most cases too unsafe to approach: it was therefore considered unnecessary to attempt any further operations in this building.

In building D, the chambers in rooms 4, 5, and 6 were loaded and tamped as in

No. 2, they having been prepared previous to the General's ordering the alteration in the mines for the piers. On firing them it was found that the charges of 40 lbs. each in the rear angles did not produce the desired effect, although the foundations were quite shaken, and rendered useless; for the wall was left standing, though much bulged.

The chambers in rooms 8 and 10 were loaded as shewn in the plan: the rear wall having been increased in thickness, and there being considerable difficulty in forming satisfactory chambers well into the angles, the rear charges under this portion were increased to 115 lbs. each, (the other angle charges being 80 lbs. each), and two of 60 lbs. each were placed in each pier wall.

The effect of these charges was very satisfactory: at the front the foundations were completely shaken and destroyed, and the whole of the wall, with a considerable portion of the piers, was brought down: at the rear the foundations were shaken, bulged, and rendered useless, but portions of the wall still remained standing, a large breach only being formed by each charge in the piers. Chambers in rooms 12 and 14 were loaded, the charges being the same as in No. 8; the effect of their explosion was perfectly satisfactory.

September 7th.—Chambers were formed in No. 19 room, and charges were lodged in Nos. 16 and 18.

Brigadier General Jones arrived about 11·30 A.M., and left at 2 P.M. The charges in Nos. 16 and 18 were fired at 1 P.M., and the effect produced was very satisfactory. The foundations were completely shattered and rendered useless, and the front and rear walls were thrown down: only small portions of the piers were left, and these were so shaken that it was dangerous to approach them. The charges in No. 19 were placed and fired, and the effect was very good, although the charge of 64 lbs. at the extreme right front did not explode.

The chambers in the small rooms adjoining No. 1 were loaded: the charge of 80 lbs. at the extreme left rear being lodged from the outside, on account of the difficulty of forming a satisfactory chamber on the inside. The explosion of these charges reduced the left end of the building D to a heap of ruins.

September 8th.—On examination, the powder hose attached to the charge of 64 lbs., on the extreme right front of the building D, was found to be cut; it was replaced, and the charge was fired with effect, bringing down the remaining portion of the front wall.

Six charges were lodged in the rear walls of Nos. 3, 4, 5, 6, and 7, advantage being taken, in two or three instances, of the ventilating holes passing through the walls about 1 foot above the level of the ground: the explosion of these charges brought down the whole of the rear wall.

Four charges were also placed in the rear walls of Nos. 9, 10, and 11, two of these being lodged in ventilating holes; and their explosion brought down the whole of the rear walls, which were previously much shattered.

Nine chambers were formed in the foundation of the building marked B in Plate 4, at the end nearest to A, those at the four angles of the end casemate were loaded with 60 lbs. each, and those in the rest with 50 lbs. each: a charge of 40 lbs. was also placed at the centre of each pier. This building consisted of the foundations for 18 casemates, 57 feet × 18 feet, in the clear; the front and rear walls being 7½ feet thick, and piers 7 feet thick.

The walls of that half of the building next to A had been carried up to a height of 12 feet, but the foundations of the other half were only just traced out. The front wall had a facing of hexagonal blocks of granite averaging 2 feet in depth.

The rooms at the end next to A had been filled up, to a height of 6 or 8 feet, with earth and loose stone, through which shafts were sunk in order to lodge the powder well under the foundation; the materials for tamping were thus close at hand. The effect of the charges lodged here was most satisfactory, the foundation being completely shattered, and the walls brought down in a heap of ruins.

September 9th.—Chambers were formed in the foundation G; the side walls of this building were 4 feet 6 inches and 4 feet thick; the end walls 4 feet 6 inches, and piers 5 feet thick The walls at the end nearest to the main fort had been carried up to a height of 7 feet 6 inches above the ground, and were faced with granite to a depth of 2 feet. Charges of 30 lbs. and 20 lbs. each were placed at the angles, and at intervals of about 24 feet.

Chambers were also formed in the foundation F. The walls of this building had been raised to the same height as those of G, at the end towards the main fort; but the foundations of both towards their other ends could scarcely be traced. The charges were placed in the same way as at G.

Chambers were also in progress at the foundation of the tower C, and at B. The tower C was intended to be similar in form to that called Nottick, but its diameter was 180 feet; its walls had in some few places been carried up from 4 to 6 feet, but generally only 12 to 6 inches, and in some places the foundations were hardly discernible. Charges of 60 lbs. were placed at the front angles, and 30 lbs. at the rear angles of the rooms.

In part of a pier wall left standing in No. 4 Room, in the building D, a charge of 10 lbs., placed nearly in the centre of the wall immediately above the rubbish, produced a breach 6 feet high and 3½ feet wide.

At 6·45 P.M. the mines in F and G were fired, the effect produced was perfectly satisfactory, the whole of the work being completely shattered, and the walls being all brought down in a heap of ruins. At 7·10 P.M., the remainder of the charges in B were fired with remarkably good effect, and at 7·25 P.M. those at C were fired, except one which did not explode.

September 11th.*—The fuze attached to the charge at C, which did not explode, was found not to have been ignited, owing to the darkness of the night.

Two more chambers were formed at C, and others were commenced at foundations A and E.

The building A consisted of the foundations of 19 casemates, of the same dimensions as those in B; the front wall and those at the end nearest to the main fort were raised to a height of 3 feet to 4½ feet, and the spaces enclosed by them were filled in with earth and large stones, whilst the rest of the foundations were only raised 12 inches to 6 inches above the ground. The front wall was faced with hexagonal blocks of granite, from 2 feet to 2½ feet thick.

The building E consisted of the foundations of 15 casemates, each 60 feet × 18 feet in the clear, with some smaller rooms at its junction with D. The front walls were 7 feet thick, and the rear walls 5½ feet thick: the piers were 6½ feet in thickness. Towards D, the walls had in some places been raised to a height of 10 feet, whilst at the other end the foundations were hardly visible. The front wall was built like that of A.

The charges used in E varied from 20 to 50 lbs. each, and were placed at the centre of each pier, and at each of their ends.

Twenty eight chambers in F were loaded by 6·30 P.M. and fired. Three of the charges did not explode, but the result of the rest was perfectly satisfactory, the foundations being completely shaken and destroyed, and the walls brought down in ruins.

September 12th.—In two of the charges which did not explode on the previous night, the fuzes were found to have been detached from the powder hose; in the

* September 10th being Sunday, no work was done on that day.

other the hose was found to have been cut close to the charge. The hose and fuzes having been replaced, the charges were fired with good effect.

Twenty-one chambers were formed in E, and their charges were fired with excellent effect, completing the demolition of these foundations.

Eighteen chambers having been formed in A at the front end of each pier, they were loaded with charges of 30 lbs. each, and fired; the demolition of the foundation was thus completed, the remaining walls not having been raised high enough to admit of charges of powder being placed under them with any effect.

In a stack of bricks, 90 feet long, 14 feet wide, and from 5 feet 6 inches to 7 feet high, thirteen shafts were made at equal intervals along the centre, charges of 12 lbs. were placed in them at the level of the ground, and the bricks were tamped in again: the charges were ignited by Bickford's fuze, and the effect produced was tolerable, a good proportion of the bricks being broken by the explosion.

In the Pier-head five chambers were made, as shewn in Fig. 4, Plate 3. Its dimensions were 42 feet 3 inches × 21 feet 2 inches; the coping was 3 feet 10 inches above the water line, and the front and sides were revetted with rectangular blocks of granite from 2 feet to 1½ feet in thickness, well cemented, and connected by iron cramps. Shafts were sunk until the water appeared (at a depth of 4 feet), and as good a chamber as possible was made for each of the charges (which were all 36 lbs.): a quantity of stone and rubbish, which was on the spot, was used for tamping, and the effect of the explosion was most satisfactory, the whole of the pier-head appearing to slide off into the water, rendering approach impossible for any boat drawing more than 1 foot.

September 13th.—In order to destroy as much as possible of the rear wall of the Officers' Quarters in the Main Fort, which remained standing, though much shaken, 11 charges of 12 lbs. each were placed in the loop holes, the interior part of each having been tamped with bricks: the charges were then built up with dry bricks, and fired by means of "Bickford's fuze." Their effect was to shake the walls in several directions, and in one or two instances to knock two loop holes into one.

A small portion of the rear wall of the chapel being still left standing, one of the stones of the plinth-course was taken out, and a chamber formed in the hole about 1 foot deep. A charge of 64 lbs. of powder was placed in it and well tamped. It was exploded by means of Bickford's fuze, and the effect was to bring down the whole of the granite facing, and form a breach in it, as shewn in Plate 1, 30 feet high and 26 feet wide, leaving the brick and rubble behind quite uninjured.

A working party of 100 seamen, from H.M. Ships "Ajax" and "Leopard," was employed daily after the 5th September, in carrying bricks for the tamping, lighting fires round cut granite, and destroying bricks.

The demolitions ordered to be carried on having been completed, a report to that effect was made to Brigadier General Jones at Led Sund.

OBSERVATIONS.

The charges used in the operations for the demolition of the foundations varied from 20 lbs. to 115 lbs., according to the length of the line of least resistance and the nature of the chamber; 30 lbs. placed in a good chamber and well tamped being found to produce as good an effect as double the quantity of powder, where a satisfactory chamber and tamping could not be procured. The effect produced by a charge of

40 lbs. in foundation F, lodged in a *drain*, and well tamped, was most satisfactory, the line of least resistance being about 5 feet, and brick being the material used for tamping.

In general, from 30 lbs. to 50 lbs. may be taken as having been found to give satisfactory results, with lines of least resistance of 3 feet to 6 feet.

The effects of charges lodged in the pier walls of building D were always of the same nature, an opening having been made through them proportionate in size to the quantity of powder used.

An experiment was made at foundation C in sinking holes in the masonry with a jumper, but it was found impossible to make progress, owing to the hardness of the granite blocks.

Wherever the foundations had not been raised high enough to admit of powder being used with advantage, the stones on the top were moved off, and loosened with picks and crow-bars, so as to let the frost well in when the winter advanced, and thereby destroy them and render them useless.

The powder was landed from her H.M.S. "Ajax" in boxes, containing flannel cartridges of from 5 lbs. to 20 lbs. each, which were very convenient for packing in the chambers.

After the first day, all the charges were fired with Bickford's fuze, a length of 5 feet being generally attached to the powder hose ; not the slightest accident occurred during the operations, although the greatest difficulty was constantly experienced in clearing away the inhabitants and seamen before firing. All the charges were generally fired at the end of the day's work, after the seamen of the working party had returned to their ships, the ground being cleared by the guard of Royal Marines.

There being a quantity of granite on the spot, cut and prepared for building, it was found that the easiest mode of rendering it useless was to light fires on and close to it : the application of strong heat for half an hour cracked and split the stones in all directions, whilst it took an experienced stonecutter an hour and a half to render one small block unserviceable by means of a sledge-hammer.

Return of Powder Used in the Demolitions at Bomarsund.

In building A	540 lbs.
" B	1,400 "
" C	360 "
" D	5,573 "
" E	1,994 "
" F	580 "
" G	340 "
Chapel and Officers' Quarters ..	1,896 "
Pier	180 "
Pile of Bricks	156 "
	13,019 lbs.
For Powder Hose	479 "
Total expended	13,498 lbs.

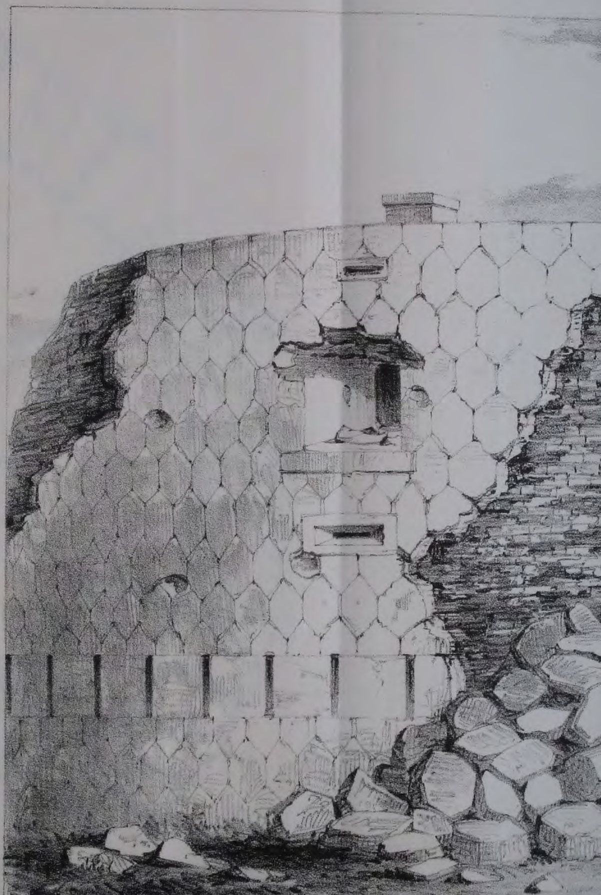
Portfires (No.) 33.
Powder hose (yards) 750.
Bickford's fuze (fathoms) 450.
Slow match (lbs.) 5.

Signed, FRED. WM. KING, Captain Royal Engineers.

Record of Charges, &c., for Demolitions at Bomarsund, in accordance with Brigadier General Jones's memorandum, dated September 1st, 1854.

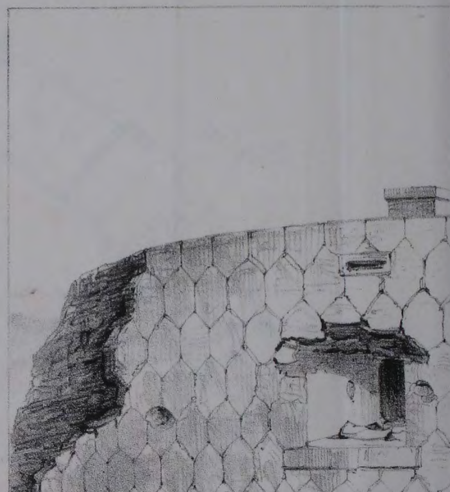
Date.	No. of charges.	Situation of charges.	Quantity of powder in lbs.	Nature of tamping, &c.	Effect.	Remarks.	Number employed.		Time in making chambers.		Time in tamping.		Remarks.
							N. C. O.	Men.	Hours.	Min.	Hours.	Min.	
Sept. 4th.	6	D	360	Bricks, timber, &c	very good	Portions of piers left.	2	18	3	30	2	55	The scaffold poles were much in the way.
,, 5th.	2	Chapel	1,200	Casks, bricks, &c.	good	Lodged on ground.	2	10	—	—	2	30	Remainder of company were employed commencing other chambers in D.
,, 6th.	2	Chapel	500	do.	good	Lodged in oven and boiler							
—	44	D	3,100	Bricks, timber, &c	very good	Portion of front wall left.	19	65	16	—	10	—	
,, 7th.	32	D	1,968	do.	very good		19	63	7	—	4	—	
,, 8th.	10	D	135	Bricks.	good	Lodged in front wall.							
—	9	B	490	Earth and stones.	very good	Chambers generally good.	18	64	6	—	4	30	
,, 9th.	1	D	10	Bricks.	good	Lodged in pier.							
—	18	F	580	Earth, stones and bricks.	very good	Chambers good.							
—	12	G	340	do.	do.	do.	18	65	7	—	3	45	Seamen assisted in mining.
—	25	B	910	do.	do.	do.							
—	6	C	240	do.	do.	Chambers not very good.							
,, 11th.	3	C	120	do.	do.	Chambers good.							
—	28	E	1,274	do.	do.	do.	18	65	7	—	3	30	
,, 12th.	21	E	720	do.	do,	do.							
—	18	A	540	do.	do.	do.							
—	13	Pile of brick	156	Brick.	moderate		19	63	7	30	3	30	
—	5	Pier head	180	Earth and stones.	very good								
,, 13th.	11	Officers' qrs	132	Brick.	moderate	Charges placed in loop holes							
—	1	Chapel	64	Bricks and stones.	good	Lodged from outside at about centre of wall at the plinth.	2	20	2	—	1	—	The remainder of the Sappers were employed uncovering foundations, &c.

Signed FREDERICK WM. KING, Captain, Royal Engineers.



SKETCH OF PART OF THE MAIN WORK AT BOMARSUND, SHEWING ITS

J. C. Cowell, Lt. R.E.



SKETCH OF PART OF THE MAIN WORK AT BOMAR

J.C. Cowell, Lt. R.E.

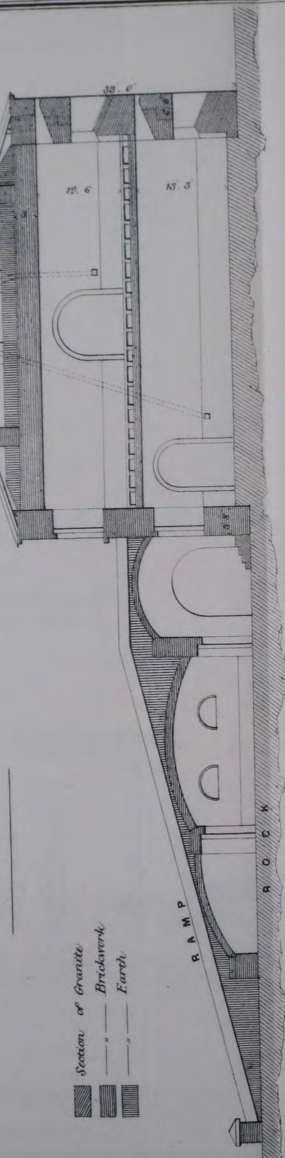
PL. I.

D, SHEWING ITS CONSTRUCTION & THE EFFECT OF A CHARGE OF 64 lbs.

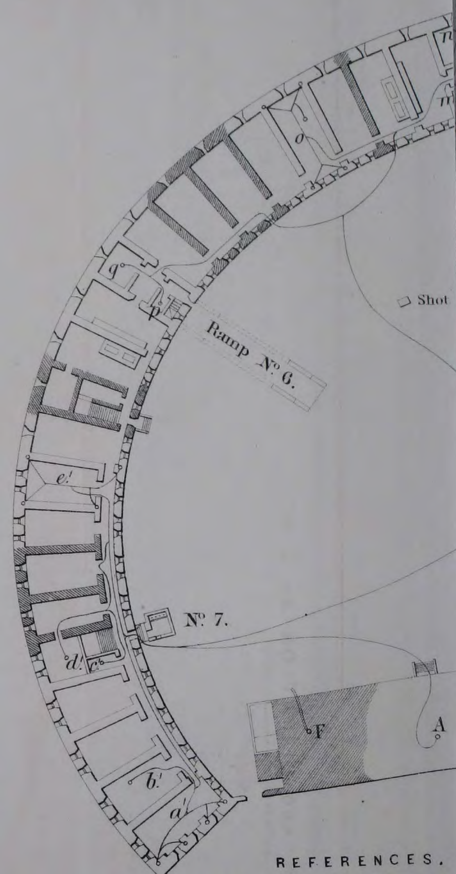
Printed by C. Moody, 257, Holborn.

SECTION AND ELEVATION ON G. H.

Scale $\frac{1}{240}$.



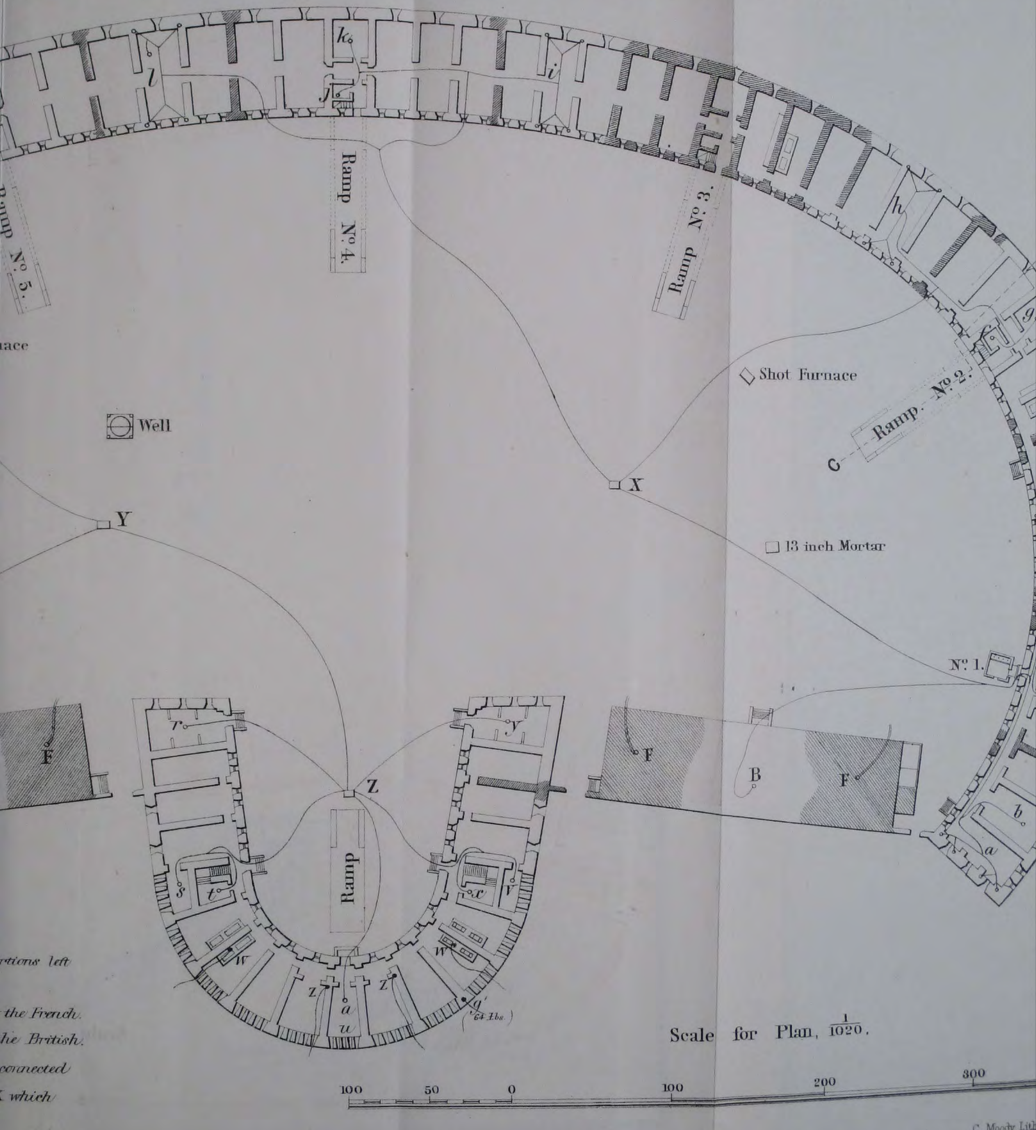
PLAN



REFERENCES.

The parts in the plan shaded are the
standing after the explosions.
The small circles shew the charges lodge
The dots z, w, g' shew the charges lodged
All the charges lodged by the French
with two boxes containing mealed powde
were fired at the same time as F. F.

OF MAIN FORT OF BOMARSUND.



PAPER IV.

Description of a Diving Machine,

Employed in the Government Works at Cherbourg by Dr. Payerne.

By CAPTAIN H. TYLER, Royal Engineers.

During a recent visit to Cherbourg, Dr. Payerne was kind enough to explain his ingenious diving machine to me; he had not any drawing of it, but from the dimensions with which he furnished me, and from observation, I made the accompanying sketch, which, with the explanations attached, is probably sufficient to show its general construction. The irregularity in the shape and curvature of the machine is partly owing to its having been lengthened since it was first built. Its present form, if it were closed below, would appear to be more fitted for a locomotive, than for a mere stationary diving vessel.

Unfortunately, the machine was under repair at the time of my visit, and I was therefore prevented from going to any great depth in it; but I was under water for upwards of half an hour; and, during that time, we went through all the manœuvres of ascent and descent, and pumping air and water from and into the different compartments, with perfect success. There were present Dr. Payerne, Mr. Hammond, (the British Consul), the Hon. L. Hope, and four men to work the pumps and attend to the machine. We were steady in the water, although the iron weights used for ballast had been removed from their proper position in the reservoirs C, C′, and were lying about the lower deck.

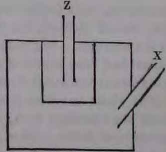
The whole machine is constructed of iron plates rivetted together. The plates to cover the openings at A, M, Q and Q′ are secured by iron screws, with a slip of vulcanized India rubber round the edges; and as these screws are perhaps more numerous than necessary, some time is wasted during the ascent and descent of the machine, in unfastening and securing the openings. A much larger hatchway can, on occasion, be opened at M, to give the men more room to work at the bottom. There are two pumps on opposite sides of the chamber L, one capable of performing all the operations that can be required in any compartment,* but the other more limited in its powers. The Doctor states that, in another machine, it would be better to have two pumps of equal dimensions, each capable of doing all the work, in case of accident. Eight men labour in the chamber P, and a ninth man remains in

* See E in diagram, and the explanation.

the chamber L, to purify the air, to receive the débris of the work, to admit fresh air from the chambers B, B′, (an operation which is necessary every hour), and to attend to the machine. The weight of the machine is 22 tons, and that of the ballast, including the weight K, 40 tons. The total weight therefore is 62 tons.

The great advantage of this machine over the ordinary diving bell is that it is independent of the surface, both as regards its supply of air, and its means of ascent and descent.

The supply of air is, in practice, derived entirely from the reservoirs B, B′, into which the air is condensed by pumping, previous to the descent. The carbonic acid gas exhaled from the lungs of the occupants being heavy, falls to the bottom, and if the machine descends in running water, is absorbed by and carried away in the current; but in still water, as the water can only dissolve a small quantity of the gas, an ingenious though simple method of getting rid of the remainder is resorted to. The air is passed through lime water, by means of a common bellows, and thus freed from the carbonic acid it contains, which is precipitated as carbonate of lime. The operation is continued for a quarter of an hour, and an equal time is allowed to elapse before it is recommenced. A little potash is required to make the lime dissolve, and as much lime is used as will saturate about six gallons of water. Such a mixture will last for a long period. The carbonic acid gas being thus completely absorbed by the lime, the atmosphere of the machine ceases to possess any hurtful property, and requires nothing more than its hourly supply of pure air from the compartments B, B′ to make it healthful. Dr. Payerne states that, in practice, he has never had occasion to employ other than these means, and that he has found them amply sufficient in all cases for a day's work. In remaining under water for a more lengthened period, it would become necessary to add from time to time a certain amount of oxygen. The nitrogen, with the exception of a trifling quantity, which goes to form ammonia, is exhaled from the system in the same state in which it is inhaled, and is fit to be breathed over again any number of times; but, as the oxygen is entirely consumed in the system, the atmosphere of the machine would, in time, consist of nitrogen alone, which gas is not capable of sustaining life. The water, too, rises in the machine in proportion to the amount of oxygen consumed, and the quantity of carbonic acid gas absorbed. To supply, therefore, the only substance required, namely, the oxygen, the following means are employed.



The apparatus shewn in the section consists of two pots, one inside the other, the larger to act as a furnace for heating the smaller. Through the opening Z is introduced a mixture of two parts of chloride of potash and one part of peroxide of manganese, and, into the lower pot, through the opening X, little balls are dropped as required, consisting of one part of coke, and, either five of nitrate of soda, or six of nitrate of potash; the duty of the soda or potash being to supply oxygen to support the combustion of the coke. A few grains of gunpowder being sprinkled over the bottom of the lower pot, these balls are easily ignited at any time by the introduction of a common match through the opening X. Oxygen is given off in any required quantity from the opening Z, and the smoke is conveyed away through a funnel leading downwards to the exterior of the machine, whence it finds its way in bubbles to the surface.

The descent and ascent are managed by merely pumping water into the chambers B and C, and B′ and C′, when descending, and by pumping it out again into the sea for the purpose of ascending. When the machine is at the surface, the door at A is open, and that at M is screwed down. The machine is then buoyed up by the air in the chambers B, B′, and P. To descend, the door A is secured, and air is let into L from B and B′, until the air in L is in about the same state of compression as the air in P. The door M is then opened, and water is pumped from the sea into the chambers B, B′, and C, C′, until the machine sinks to the bottom. In ascending, the course pursued is precisely the reverse: and, in case of accident, by throwing out a few tons of the iron ballast, the machine might be made to rise at once to the surface. The machine has been employed by Dr. Payerne for excavating rock, for the purpose of deepening the channel, at the entrance to the southern basin in the port of Cherbourg. The material excavated is carried up in the machine; but it would probably be more economical to employ a man at the surface to haul it up, as the time of the eight men in the interior would thereby be to a certain extent saved, and the labour of pumping out an amount of water equal in weight to the material, be avoided. If the machine descend on an uneven bottom, or come in contact with a rock, so as to tilt it up on one side, the weight K is lowered, the machine rises, and, if necessary, is pushed by a pole into a different position. There is no difficulty in moving it slowly about, under water.

Light is admitted, as in the ordinary diving bell, through lenses or bull's eyes, as shown at N; and this is sufficient, in clear water, at any depth to which it is practicable to descend. Dr. Payerne limits this depth to about 140 feet. He has not yet burnt a light or a candle in his machine. To enable him to do this, a slight current of air would require to be produced, and, probably, a funnel, for the escape of smoke and smell to the exterior, would be necessary.

A very superficial comparison of the merits of this machine with those of the ordinary diving bell, will, I think, serve to show its superiority. With the ordinary bell, at least eight men are required at the surface, to manage the pumps and machinery connected with it, whilst one or two men work at the bottom of the water; but in this machine, the work of eight men out of ten* is available for building, or excavation, under water.

The time occupied in ascending and descending is, at present, greater in this machine, than in the ordinary bell, by perhaps, on an average, half an hour for every 40 feet, but I imagine that some better means might be devised than pumping water in and out; as, for instance, attaching to the machine several such weights as K, which might be lowered by ropes to the bottom when the machine is required to rise, and be hauled upon when the machine is required to sink. The necessary amount of water ballast might be retained in the machine, and pumped out only when it is necessary to raise the weights to the surface in the machine, for the purpose of removing to another locality. For searching a wreck, or laying a charge of powder, or for any case in which mere inspection is necessary, the diving helmet and dress must ordinarily be more suitable than either this machine or the common bell; but for excavating, or building under water, Dr. Payerne's machine would appear, even in its present state, to be far superior to the old diving bell. Dr. Payerne states, that the machine now working at Cherbourg, being his first experiment on a large scale, has many faults of construction, in shape, and in other respects, which he is prepared to correct in the next vessel he builds. The work done by the machine is paid for by the French Government according to the quantity excavated; and the nine men excavate somewhat less than a cubic yard and a half of hard rock in six and a half hours, besides ascending and descending usually twice in that time.

* Nine men in the machine, as previously explained, and one man at the surface, in a boat, who communicates with the machine by means of a box, which is hauled up and down, and in which any wants are expressed in writing, and any tools, or other articles required, are sent down.

Dr. Payerne is confident of being able to apply steam power to a vessel of this description for locomotion, by means of a screw. He proposes to employ a common tubular boiler, and to use a furnace similar to that already described, but of large dimensions, for the generation of oxygen; and he states, that, although the expense has prevented his trying the experiment on a large scale, he has so tested the scheme as to be certain of success in subaqueous navigation. He estimates the cost of fuel at 1s. 8d. (two francs) per horse power, per hour.

A vessel capable of locomotion under the surface of the water, would not probably be of much practical utility, excepting as an engine of war; but, for this purpose, if capable of direction, it would doubtless be of great value; and, on that account, as well as for more peaceable objects, I recommend it to the attention of my brother officers.

H. W. TYLER, Lieut. R.E.

9th February, 1853.

EXPLANATION OF SKETCH.

A. The door through which communication is maintained with the exterior, when the machine is at the surface.

B. B′. Reservoirs into which compressed air is pumped, or water, when the machine is required to sink.

C. C′. Compartments containing about 36 tons of iron ballast in small blocks. A free communication exists between them and the chamber L. Water is pumped into these compartments during the descent.

D. Iron stays to which a pulley is sometimes affixed, to facilitate the removal of heavy materials when the machine is at the surface.

E. One of the pumps. It is capable of pumping air from the exterior into the chambers B and B′, so as to condense it to the extent of two atmospheres, when the machine is at the surface; or of pumping air from the chambers B, B′ into L and P, so as to produce, if necessary, a partial vacuum in the chambers B, B', when the machine is immersed. It will also pump water from the sea into the chambers B, B′ or C, C′, or from either of these chambers into the sea.

F. F′. Cocks for admitting the condensed air from the chambers B, B′ into the machine.

G. G′. Pipes for pumping water into the chambers, B, B′, or through which air may be pumped to or from the chambers B, B′.

H. H′. Pipes for emptying the chambers B, B′ of water.

K. A weight of about 4 tons, which may be lowered on arriving at the bottom of the water, if it be necessary to ascend a little, and which may be again hauled upon in order to descend.

L. Chamber in which the pumps are worked, and where the excavated materials are lodged.

M. Door to communicate between chambers L and P.

N. Lenses or bull's eyes for the admission of light.

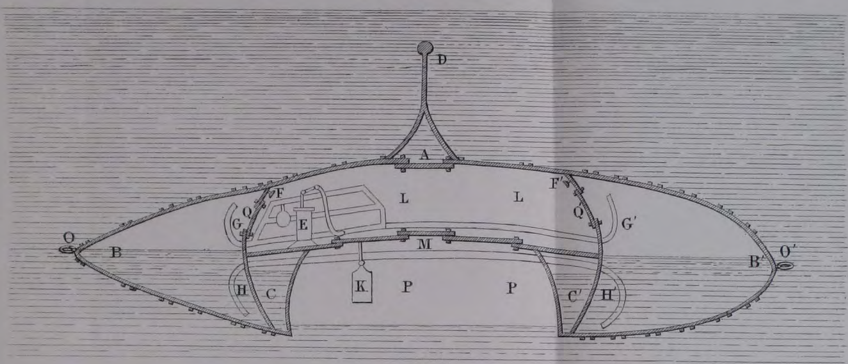
O. Rings by which the machine may be secured or towed.

P. Working chamber always open at the bottom.

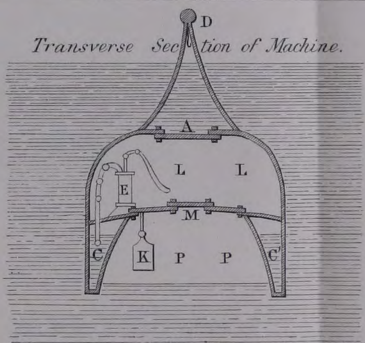
Q. Q′. Communications between the chambers B, B′, and L, for cleansing or other purposes.

DIVING MACHINE USED AT CHERBOURG BY Dr. PAYERNE.

Longitudinal Section of Machine immersed.

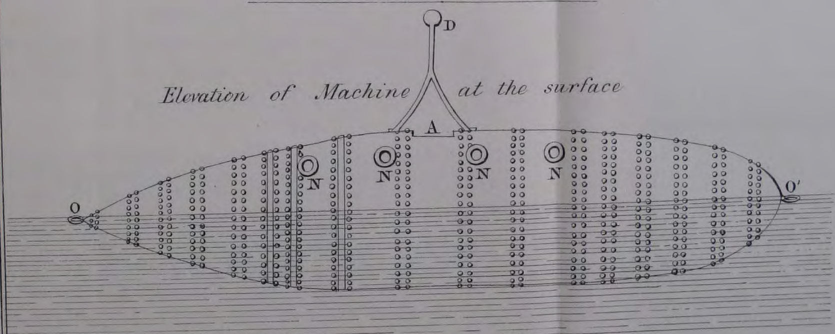


Transverse Section of Machine.



N.B. The water is shewn by thin horizontal lines

Elevation of Machine at the surface



10 5 0 10 20 *30 English Feet.*

H. W. Tyler, 7th Feby 1853.

PAPER V.

Records of Experiments on the Accumulation of Smoke caused by Firing in Casemates.

As it is of course necessary in the construction of casemated works to consider well whether there will be sufficient means of carrying off the smoke produced by firing from them, I have obtained the following extracts from the Records of the Royal Engineer Establishment at Chatham, describing experiments on the effect of musketry fire in a caponier at that place, and I have translated the "Procès verbal," relative to trials made to prove the effects of artillery fire in a Tower-bastion and casemated flank, built by Vauban at Neuf Brisach, and have inserted it below, in order to assist in determining the size of the apertures required for ventilation.

I may also remark that experiments were made some years ago in a counterscarp gallery at Portsmouth, which proved that in those also no difficulty would arise in maintaining a continuous fire of musketry from them; and that it is evident that the use of percussion locks has proved very advantageous in preventing the difficulty anticipated in getting rid of the smoke in casemates.—Ed.

Records of Experiments made at the Royal Engineer Establishment at Chatham.

Communicated by COLONEL SANDHAM, R.E., Director.

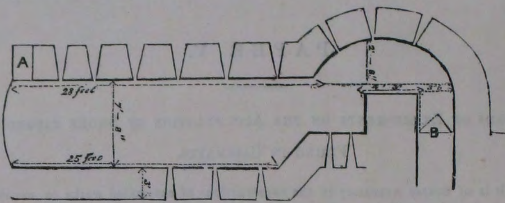
Royal Engineer Establishment,

Chatham, 9th October, 1845.

In order to ascertain the extent of inconvenience resulting from smoke, occasioned to troops firing from a loop-holed building, a party of Sappers, armed with percussion carbines, were this day placed in the caponier at the left of Chatham Lines.

This caponier is of masonry, and is of the form shewn in the plan. The principal passage is 39 feet long, 7 feet 6 inches wide, and 8 feet 9 inches high to the crown of the arch, it has loop-holes for musketry in the two opposite walls, viz., nine in one and five in the other; these loop-holes have a width of 4 inches, and a height of 1 foot in the interior, and are 1 foot wide at the exterior.

The caponier has two ventilators, but these were stopped up during the experiments. Two doors open into this caponier, one from a gallery which flanks it at the end A, and the other which leads into another gallery at the end B.



Case 1.—The five loop-holes on one side were blocked up, as well as the doors and ventilators, and there was no opening of any sort to admit air, except through the nine loop-holes on the other side of the caponier. Two Sappers were then placed at each loop-hole, and after firing blank cartridges for 18 minutes, the barrels of their carbines became so hot that it would have been dangerous to load any more. Not the slightest inconvenience was however felt from the accumulation of smoke.

Total number of rounds fired, 708, that is, nearly 79 rounds to each loop-hole.

Case 2.—The smoke having been allowed to clear away after the first experiment, all the loop-holes were opened, but the doors and ventilators were still kept closed. 22 Sappers then commenced firing with blank cartridges, and at the end of 8 minutes the caponier became full of smoke, and the men could not have kept it up much longer.

Total number of rounds fired, 545, that is, nearly 39 rounds to each loop-hole.

OFFICERS PRESENT.

Captain G. Whitmore.
" E. Lloyd.
" J. McKerlie.
Lieutenant G. Tilly.
" C. Chesney.
" E. De Moleyns.
" T. Armit.
" C. Ewart.

(Signed) EDWARD C. DE MOLEYNS,
Lieutenant, Royal Engineers.

Royal Engineer Establishment,

Chatham, November 21st, 1845.

In continuation of the experiments made on the 9th of October last, for the purpose of ascertaining the effect of firing continuously in loop-holed buildings; the trial was renewed on the 20th instant, but with the difference of the two ventilators (which are opposite each other at the outer extremity of the caponier) being opened.

Case 1.—The five loop-holes on one side being blocked up, two Sappers were placed at each loop-hole on the opposite side, and the firing was kept up incessantly till 40 rounds had been fired at each loop-hole, or 360 in all, when there was no perceptible thickening of the air, the smoke not appearing to settle inside at all.

Case 2.—The loop-holes on both sides being now opened, two Sappers were placed at each, and as before, 40 rounds per loop-hole were fired continuously, or 560 in all. The result was that after the first few rounds the air was a little smoky, but did not continue to get at all more so during the remainder of the firing.

N.B.—The firing lasted about 27 minutes, and there was rather a strong wind at the time.

The total area of the ventilators was about 7 square feet.

There were present at the above experiment the following officers of Royal Engineers,

Captain Lloyd.
Lieutenant Stace.
" Stanton.
" Chesney.
" Armit.
" Ewart.

(Signed) C. C. CHESNEY,
Lieutenant Royal Engineers.

"PROCÈS-VERBAL" OF THE EXPERIMENTS MADE, RELATIVE TO THE SMOKE PRODUCED BY FIRING IN THE CASEMATES AT NEUF-BRISACH, ON THE 7TH BRUMAIRE, 8TH YEAR OF THE REPUBLIC (1799), UNDER THE ORDERS OF GENERAL DESNOYERS, COMMANDANT OF THE DEPARTMENT OF THE UPPER RHINE.

"On the 7th Brumaire at 3 P.M., the General went into the casemate of Tower-bastion No. 1, accompanied by the Commandant of the place and many other officers.

This casemate extends along the faces, flanks, and gorge of the Tower-bastion, round a large mass of masonry, which serves as an abutment for its arches, and which contains in the centre a small powder magazine.

The casemate is 6 mètres wide, its length is nearly 56 mètres, and the height to the crown of the arc h is 4·33 mètres, its floor is 3 mètres below the interior area of the fortress, and 1·33 mètres above the bottom of the ditch; the entrance to it is by an arched passage, 4 mètres wide, under the rampart.

In each flank there are two embrasures, the cheeks of which have, on the inside, the form of window jambs, and the openings of which are 1·06 mètres wide by 1·19 high, (3 feet 6 inches by 3 feet 11 inches). There is no embrasure or loop-hole along the faces of the tower; immediately over each embrasure air holes are formed of the shape and dimensions of chimney flues, and at the back of the casemate there is an ordinary chimney.

All these flues had been carefully cleaned, and all the doors had been kept wide open. Four 4-Pounders had been mounted in readiness for firing, one at each embrasure, and gunners were placed in readiness to relieve those who could no longer continue to serve the guns.

The General ordered the firing to commence exactly at 2·30, beginning with the two guns placed on the side where the wind, blowing into the casemate, was likely to drive the smoke back. Twenty-five rounds were fired in 15 minutes, using nothing to fire the guns but slowmatch, and gunpowder on the vent field: the smoke made no disagreeable impression upon any one. After 15 minutes the General ordered 35 rounds to be fired in 15 minutes more, employing a tube in the vent, and a portfire. A little more smoke was remarked, which spread itself through the casemate; it was thicker and the smell was more disagreeable than before, which arose from the composition in the portfires, nevertheless there was nothing to cause sensible annoyance, so that, having quite proved that the same gunners could continue to serve the guns rapidly in the casemate for several hours, the General did not consider it necessary to continue the experiment, and ordered the firing to cease.

He then went to the casemate of the short flank of the curtain, to the left of the Tower bastion before mentioned.

The floor of this casemate is at the same level as that of the Tower bastion, it has the same height and the same width, viz., 6 mètres. It is 24 mètres long, of which length a ramp, leading into it from the interior of the fortress, occupies 8 mètres.

This casemate has one embrasure of the same form and dimensions as those in the Tower-bastions, and it has one ventilator, formed like a chimney flue, over the embrasure.

A 4-pounder gun was placed at this embrasure, and the same gunners who were employed before wished to continue the fire without being relieved: they used a tube and portfire, and fired 20 rounds in 15 minutes, after which time the smoke had become rather dense; their eyes did not seem to be much affected by it, but they said that they felt the lungs a little oppressed, not so much by the smoke from the powder as by the gas from the portfires; and that, with the aid of a little brandy, they were sure that they could continue to serve the guns in the casemate as long as might be necessary.

The General, considering it useless to expend any more powder in this way, ordered the firing to cease.

It may be concluded that as the casemates in the flanks of the Tower-bastions, and of the curtains, at Neuf-Brisach are only intended to repulse an assault on the body of the place, which cannot last for a long time, those of the Tower-bastions would prove perfectly efficient, and those in the small flanks of the curtain would be the same, but with the inconvenience of being obliged to relieve the gunners every quarter of an hour.

Special Remarks.

1.—Observations were made on the escape of the smoke by the ventilators or air holes; it appeared to be pretty rapid for a few moments after each discharge, but this did not continue. It was thought that, as they were pierced over the neck of the embrasure, they could receive and discharge the smoke very well at first, but that they could not do so as soon as the smoke, extending itself, mounted to the crown of the arch inside; and it was believed that it would be desirable, in constructing casemates of this description, *to multiply the air-holes and distribute them along the crown of the arch.*

2.—It was observed that immediately after the discharge of the gun, the smoke, which was first driven outwards, returned through the embrasure, which was attributed to the reaction of the air outside.

3.—It was thought that as the portfire composition, which was employed to render the fire more rapid, had been the principal cause of the annoyance from the smoke, it would be desirable to try to obtain that advantage by some other means.

4.—On the day after the experiment it was remarked that some smoke still remained in the casemate of the small flank of the curtain, and that the firing had shaken the outer door of an adjoining sally-port. A careful inspection was therefore made to discover if there were any traces of the casemates having been injured during the experiment, but none were found.

5.—It was thought that the dust from the masonry, set in motion by the firing, caused a great part of the annoyance, attributed at first to the smoke, and *that it might be useful to have the walls and floors well swept before opening fire.*

6.—The use of portfires in the small flank casemates may be superseded by that of quickmatch and a tube fixed in the vent, so as to render the firing rapid without causing so much smoke as to make it difficult to point the guns."

PAPER VI.

Notes on the Effects of Enfilade Fire with Shells, upon the Parapet and Traverses covering a Rampart.

From the "Archiv für die Officiere der Königlich Preussischen Artillerie und Ingenieur Corps."

Translated by CAPTAIN BAINBRIGGE, Royal Engineers.

Attempts have been made to obtain greater results from *ricochet* fire by increasing the elevation and decreasing the charges used; but the destruction of the parapets and traverses protecting the guns on the rampart to be enfiladed, so that they may be exposed to *direct fire*, is also an important object, and the following experiments were made at Berlin to test the effects of shells fired into earthen parapets for this purpose.

1st. Experiment.—The parapet which covered the work against which the fire was directed was 27½ feet thick and 6½ feet high, and its crest was 17½ feet above the plane of site; two traverses were built across the face to be enfiladed, one constructed with two tiers of gabions, and 10 feet thick at the top, the other of earth only and 17½ feet thick; the first of these was 56 feet from the salient, and the other was 124 feet from it.

A 25-pounder brass howitzer (the diameter of the bore of which was 8·93 inches) was placed on the prolongation of the face of the work, at a distance of 500 yards from its salient. The weight of the charge used was 5 lbs, and that of the bursting powder was 3 lbs. 170 live shells were fired at a small elevation, of which 160 struck the parapet; but of these only 132 took effect at the proper level, and 6 of the fuzes of the latter failed, so that only 126 were really effective. Even of these, 29 passed through the upper part of the parapet, and did not explode till afterwards, so that it may be said that the injury to the parapet was in fact produced by about 100 shells only, and that the last 70 produced but little effect, since the craters formed by those which preceded them were partly filled up again by their explosions.

The result was that the terreplein between the salient and the first traverse must have been rendered untenable, as there were a great many fragments of shells lying there; but the parapet was not so much injured as to expose the terreplein completely to direct fire; it is however necessary to observe that, from the parapet having been formed of loose sand, the effect of the explosions was weakened, and the craters formed were soon filled up again; also that the exterior, having a slope of ½, had little tendency to crumble down.

2nd Experiment.—The object of this was to prove what would be the effect of firing into the same parapet 25-pounder shells, with fuzes cut so that they should explode beyond the parapet (and therefore acting on it like hollow shot): in the experiment however their fuze holes were plugged up, and they had no bursting charge, but each contained 3 lbs. of sand as a substitute.

The range was again 500 yards, the parapet was repaired so as to be of the same dimensions as before, and the charge used was 5 lbs.

Four hundred shells were fired, of which only 205 acted effectively, and 112 passed over the parapet.

After 200 rounds the upper part of the parapet was found to be cut through in two places, but the hollows thus formed were only 2 feet to 1 foot deep, and the terreplein was not thereby much exposed to direct fire. After 400 rounds there was an opening 15 feet wide, but only 2 feet deep at the centre, and only 6 inches deep at a distance of 5 feet from the centre; on each side of this hollow, heaps of loose earth had been formed, so that the height of the parapet at those points was 6 inches *more* than at first. Both traverses were much injured, but they still afforded sufficient protection to the guns beyond them. Since many of the shells passed through the top of the parapet, and many passed close over it, the space between it and the 1st traverse would have been rendered untenable.

The conclusions to be drawn from these experiments are as follows:—

1.—If we keep the particular objects out of sight, and consider only the *general result* of this kind of enfilade fire, the latter will not appear inconsiderable; but as the same amount of injury to the means of defence on the rampart would be produced by ricochet fire alone from 25-pounder howitzers, with a much smaller expenditure of ammunition, and as artillery at the salient angles cannot continue their fire long after enfilading batteries have opened against them, no greater value can be assigned to that sort of enfilade fire the effect of which is confined to the space between the salient and the first traverse, and the trifling weakening and lowering of the parapet obtained by the latter cannot be regarded as particularly advantageous, since the first traverse did not thereby become exposed to direct fire.

2.—That kind of enfilade fire which affords the greatest probability of hitting the means of defence along the *whole* line of rampart, viz., ricochet fire, appears to be most applicable in general.

3.—If however it is indispensable to destroy *particular works* intended to afford cover or security against assault, (such as blindages, dams, &c.,) it will be best to employ both vertical fire from large mortars, and direct fire from heavy howitzers or shell guns.

Although the effect thus produced on parapets formed of sand was inconsiderable, we may expect better results from the explosion of large shells in parapets formed of stiffer soil, for other experiments have proved that they are likely to be destroyed more easily.

PAPER VII.

ON HYGROMETRIC OBSERVATIONS.

BY LIEUT. RENNY, RETIRED LIST, ROYAL ENGINEERS, M.R.I.A.

1.—It being very desirable to introduce the consideration of the hygrometric state of the atmosphere into the formulæ employed in determining the height of mountains by means of the barometer, it is proposed in this paper to point out the means of ascertaining the hygrometric state of the atmosphere.

2.—It has been ascertained, by experiment, that at a given temperature, only a certain quantity of vapour of water (not to be exceeded) can exist in a vacuum of given dimensions—less may exist, but more cannot: if more be injected into the vacuum it becomes deposited, that is, changed into water. If however the temperature be raised, the quantity of vapour of water may be increased without deposition. On the other hand, deposition of water can be obtained from vapour of water in a vacuum, either by lowering the temperature or by diminishing the dimensions of the vacuum containing the vapour. It is also known by experiment that the same quantity of vapour of water which can exist in a vacuum of given dimensions, and at a given temperature, can be united to dry air of the same dimensions and of the same temperature, and that the same peculiarities of vapour of water, relative to deposition in a vacuum (dependent on change of temperature or change of dimensions) belong to it in its union with dry air. When a given quantity of dry air is united to the greatest or maximum quantity of vapour of water peculiar to its temperature, the air is said to be saturated. It very rarely happens that the atmosphere is in a state of saturation. If it were so, it is obvious that the slightest diminution of temperature would cause a deposition of water. The temperature necessary to produce deposition (generally below the temperature of the atmosphere) is called the dew-point of the atmosphere.

3.—Vapour of water, being a gas or elastic fluid, obeys, of course, the laws peculiar to elastic fluids.

For example.— The temperature of vapour of water continuing unchanged, its elasticity varies as its density, and its density continuing unchanged its elasticity increases with an increase of temperature, according to the law of expansion of gas, under such increase.

Let therefore l be the expansion of gas for each degree of Fahrenheit above the freezing point (32°)

Let F be the elasticity of gas at freezing point ;

Let also f be the elasticity of the same gas at any other temperature t ;

Then supposing the density or specific gravity of the gas to be the same for both temperatures, we have

$$f = F\left\{1 + l\,(t - 32)\right\} \text{ [also } F = \frac{1}{1 + l\,(t - 32)} \quad . \; . \; . \; . \quad (A)$$

By means of equations A, we can calculate the relative elastic forces of the same gas, having different temperatures, but the same density,

Let f be elastic force for temperature t;

and f' be elastic force for temperature t';

then according to equations A we have

$$F = f \cdot \frac{1}{1 + l\,(t - 32)} \text{ also } F = f' \frac{1}{1 + l\,(t' - 32)}$$

eliminating F we have $f' = f \cdot \dfrac{1 + l\,(t' - 32)}{1 + l\,(t - 32)}$ . . . . (B)

4.—We can now easily calculate the relative elastic forces of the same gas having different densities and different temperatures.

Let d be the density of any gas.

t be the temperature of same gas.

f be the elastic force of same gas of temperature t and density d.

d' be any other density of same gas.

t' be any other temperature of same gas, having density d'.

f' be any other elastic force of same gas, having temperature t', and density d'.

Then according to equation B above, supposing the density of the gas to be d, but the temperature to be t', we have for the expression of the elastic force of the gas, the quantity $f. \dfrac{1 + l.\,(t' - 32}{1 + l.\,(t - 32)}$

But (temperature being the same) elastic force varies as density, therefore

As $d : d' :: f. \dfrac{1 + l\,(t' - 32)}{1 + l\,(t - 32}$: The elastic force corresponding to density d' and temperature t'; consequently $f' = f \cdot \dfrac{d'}{d} \cdot \dfrac{1 + l\,(t' - 32)}{1 + l\,(t - 32)}$ . . . . (C.)

5.—We have now to explain the method of obtaining a knowledge of the dew-point of the atmosphere, or a knowledge of the elastic force of the vapour of water of the atmosphere. The knowledge of either is sufficient: because by careful experiments we have ascertained the elastic forces (also called tensions) of vapour of water corresponding to different temperatures, the quantity of vapour of water being the maximum quantity peculiar to the temperature. From such experiments tables of elastic forces or tensions of vapour of water have been carefully formed, therefore when either is known, the other (with the help of such tables) can very easily be calculated.

It has already been stated that, by lowering sufficiently the temperature of the atmosphere, deposition of water can be obtained, (the temperature corresponding to deposition being called the dew-point of the atmosphere).

A very ingenious instrument, invented by Mr. Daniel (and called "Daniel's Hygrometer,") may be employed for lowering the temperature of the atmosphere to its dew-point, by means of the evaporation of ether. In making use of this instrument, the temperature indicated by a thermometer, which forms part of the instrument, is observed when deposition of water appears on the bulb of the instrument; and the temperature indicated by the thermometer is assumed to be the temperature of the dew-point.

Now if the thermometer indicated the temperature of the atmosphere the moment it begins to deposit moisture, the method recommended by Mr. Daniel would be sufficiently accurate.

It is however well known to scientific persons, perfectly competent to form a correct opinion of the peculiarities of Daniel's hygrometer, that the temperature of the dew-point, indicated by it, is always above the true temperature. For this and other reasons (to notice which is not the purport of the present paper) the employment of Daniel's hygrometer is considered unadvisable.

The method of the wet and dry thermometers is much approved of, and to explain such method we now proceed.

ON THE WET AND DRY THERMOMETERS.

6.—The method of obtaining a knowledge of the hygrometric state of the atmosphere, by means of the wet and dry thermometers, consists in applying moisture to the bulb of an ordinary thermometer placed close to another thermometer, to which no moisture is applied.

The quicksilver or spirit of wine of the thermometer to which moisture is applied immediately falls, and after a short time becomes stationary.

The degrees of temperature indicated by it, (the wet thermometer), and by the other (the dry one) being observed, furnish data to calculate the elastic force of the vapour of water of the atmosphere, and thereby to become acquainted with the hygrometric state of the atmosphere.

7.—The formulæ for making, from such data, the necessary calculations, have been first given to the scientific world by Doctor Apjohn, Professor of Chemistry at Trinity College, Dublin, and have been published in the "Philosophical Magazine" for November, 1838, in the Transactions of the Royal Irish Academy, vol. 17, page 255, and also in the Proceedings of the same Academy, and it is from these publications that the substance of this paper is taken.

8.—By way of commencement it is advisable to define some important terms employed by Doctor Apjohn, in his published papers on this subject.

Such are "The specific heat of air; the caloric of elasticity of aqueous vapour, also called the latent heat of vapour; and the caloric of liquidity of water, also called the latent heat of water."

It is known by experiment that different quantities of caloric are required to increase by an equal increment the sensible temperatures of different substances having the same weight. By sensible temperatures are meant the temperatures indicated by a thermometer. Also by careful experiments we have ascertained the relative quantities of caloric necessary to increase by one degree of Fahrenheit the sensible temperatures of different substances having the same weight. The quantity of caloric peculiar to any particular substance, under such increase of sensible temperature, is called the specific heat of such substance.

It is also known by experiment that certain quantities of caloric are necessary to convert water and other liquids into vapour, the sensible temperature being the same after, as before, the change. Thus, the caloric employed in effecting the change appears not, its presence cannot be detected by means of a thermometer. The caloric thus employed in the case of water is called the latent heat of aqueous vapour, also the caloric of elasticity of aqueous vapour.

Analogously, a certain quantity of caloric is necessary to change ice into water, the sensible temperatures of both being the same after, as before the change. The caloric thus employed is called the latent heat of water, also the caloric of liquidity of water.

8.—This being premised, when moisture is applied to the bulb of a thermometer, if the atmosphere were saturated with vapour of water no evaporation could take place, and the wet thermometer would indicate the same temperature as the dry one; therefore, the immediate sensible falling of the wet thermometer proves the existence of evaporation; and after that the wet thermometer becomes stationary, (which event quickly takes place). The caloric which it loses and that which it acquires in a given time are necessarily equal,—of this there cannot be any doubt. It is also equally certain that the caloric lost is that due to evaporation.

In Doctor Apjohn's published papers on this subject it is assumed that the portion of the atmosphere brought into contact with the wet bulb becomes saturated, and thereby receives an increase of moisture, equal to the difference between the maximum quantity peculiar to the temperature of the wet thermometer and the maximum quantity peculiar to the temperature of the dew-point of the atmosphere.

It is also assumed that the caloric acquired by the wet bulb is derived exclusively from the portion of the atmosphere brought into contact with the wet bulb, in cooling through a number of degrees equal to the difference of temperatures indicated by the thermometers.

To such assumptions it may be objected that they are without proof; but to all such objections it is sufficient to reply, that the formulæ derived by strict mathematical reasoning from the said assumptions give results abundantly confirmed by innumerable observations.

Let t be the temperature of the dry thermometer.

- f be the elastic force or tension of aqueous vapour peculiar to temperature t, as ascertained from tables of forces of aqueous vapour.
- t' the temperature of the wet thermometer.
- f' the elastic force or tension of aqueous vapour peculiar to temperature t', as ascertained by tables.
- T the temperature of the dew-point of the atmosphere.
- F be the elastic force or tension of aqueous vapour peculiar to temperature T, being the unknown quantity to be determined by the formula.
- m' be the maximum quantity of aqueous vapour which a given quantity of the atmosphere can contain, at temperature t' of the wet thermometer.
- M be the maximum quantity of aqueous vapour which the said given quantity of the atmosphere can contain, at the temperature T of the dew point.
- u be the amount of aqueous vapour formed by the caloric, supplied by the said given quantity of the atmosphere, in descending from the temperature indicated by the dry thermometer to that of the wet one, that is, in descending a number of degrees equal to $t - t'$.

9. Now according to considerations in article 8, above, the portion of the atmosphere brought into contact with the wet bulb becomes saturated, and thereby receives an increase of moisture equal to the difference between the maximum quantity peculiar to the temperature t' of the wet bulb and the maximum quantity peculiar to the temperature T of the dew-point of the atmosphere, that is, (according to our notation above), equal to $m' - M$.

But according to the same article, above, this increase of moisture is caused (through evaporation) by the caloric lost by the wet bulb being equal to the caloric gained by it, and derived exclusively from the portion of the atmosphere brought into contact with it, in cooling through a number of degrees $(t - t')$ equal to the difference of temperature indicated by the thermometers.

It therefore follows that the said increase of moisture is (according to our notation, above) also equal to u.

Consequently we have
$$m' - M = u$$
$$\text{or, } M = m' - u.$$

But as the elastic forces or tensions of aqueous vapour vary as the quantities contained in equal volumes (temperature being the same), we have, setting aside momentarily the condition of temperature,

$$\text{as } m' : M :: f' : F = \frac{M}{m'} . f'$$

Now taking into consideration the difference of temperature between that of the wet bulb t' and that of the dew-point T, and making allowance for such difference of temperatures, according to considerations in article 3, page 47, equation B, we have to replace f' in our last equation by the quantity

$$f' . \frac{1 + l. (T - 32)}{1 + l. (t' - 32)}.$$

Doing so we have, $F = \frac{M}{m'} . f' \frac{1 + l. (T - 32)}{1 + l. (t' - 32)}$

But $M = m' - u$, and eliminating M we have,

$$F = \frac{m' - u}{m'} . f' . \frac{1 + l. (T - 32)}{1 + l. (t' - 32)}.$$

Now the quantity $\frac{1 + l. (T - 32)}{1 + l. (t' - 32)}$ differing so very little from unity, (not only because l is a small quantity, but also because T and t' are very nearly equal) may be omitted with great safety—indeed it would be very foolish to retain it.

Doing so we have, after slight modification,

$$F = f' . \left\{ 1 - \frac{M}{m'} \right\} \quad . \quad . \quad . \quad (C).$$

10. In this equation C (which may be considered the fundamental equation of Doctor Apjohn's formula), the quantity f' may be regarded as known; because the temperature t' of the wet thermometer being known by observation, the corresponding force f' can be obtained from any approved table of forces or tensions of aqueous vapour. We have therefore only to obtain, in known terms, the values of u and m'.

Let a be the specific heat of air.
e be the caloric of elasticity of aqueous vapour.
e' be the caloric of liquidity of water.

Vide definitions, article 7.

Now according to our definitions and notation, a (being the specific heat of air) is a measure of the quantity of air in descending one degree of Fahrenheit. In order to fix our ideas, let the certain quantity of air be one grain in weight.

Consequently e is a proportionate measure of the quantity of caloric given out by $\frac{e}{a}$ grains of air, in descending one degree of Fahrenheit.

But according to our notation and definitions, e is also a measure of the quantity of caloric necessary to change one grain of water or moisture into vapour of water, therefore $\frac{e}{a}$ grains of air, in descending one degree of Fahrenheit, give out sufficient caloric to vaporize one grain of moisture, and $\frac{e}{a}$ grains of air, in descending $t - t'$

degrees of temperature, give out caloric exactly sufficient to vaporize $t - t'$ grains of moisture.

We may therefore in equation C, article 9, replace u by $t - t'$, provided we replace m' by the maximum quantity of vapour of water which can be united to $\frac{e}{a}$ grains of air, at temperature t' of the wet thermometer.

In order to ascertain this last quantity, let us suppose a given quantity of dry air and vapour of water, united, to be under a common pressure p, (as measured by a barometer, or by any other means whatever.)

Let f' be the elastic force of the vapour of water.

Now whereas f' is a measure of the pressure which the vapour of water sustains, $p - f'$ is obviously a measure of the pressure to which the dry air is exposed.

Let now S be the specific gravity of the dry air of the mixture or union. As it is well known by experiment that the specific gravity of vapour of water is $\frac{5}{8}$ of that of dry air, under the same or equal pressure, consequently $\frac{5}{8}$ S is a measure of the specific gravity of vapour of water under a pressure $p - f'$. But the vapour of water is under a pressure f', making allowance therefore for difference of pressures, (seeing that the specific gravity of gas varies, *cæteris paribus*, as pressure) we have $\frac{5}{8} S . \frac{f'}{p-f'}$, for the expression of the actual specific gravity of the vapour of water, at the same time that S is the expression of the actual specific gravity of the dry air.

But whereas the dry air and vapour of water occupy the same space, the quantities of each are obviously as their specific gravities, if therefore $\frac{e}{a}$ be the number of grains of dry air, we have $\frac{e}{a} . \frac{5}{8} . \frac{f'}{p-f'}$ as the expression of the number of grains of vapour of water united to $\frac{e}{a}$ grains of dry air. But the elastic force f' (being that taken from table of forces of aqueous vapour) supposes the quantity of vapour of water in union with the dry air to be the maximum quantity peculiar to temperature t'; therefore $\frac{5}{8} . \frac{e}{a} . \frac{f'}{p-f'}$ grains is the maximum quantity of vapour of water which can be united to $\frac{e}{a}$ grains of air of temperature t', both united being under a common pressure p.

We have now to replace in equation C, article 9, u by $t - t'$,

and m' by $\left(\frac{5}{8} \frac{e}{a} \frac{f'}{p-f'}\right)$

Doing so we have—

$$F = f'. \left\{ 1 \frac{t-t'}{\frac{5}{8}.\frac{e}{a}.\frac{f'}{p-f'}} \right\} = f' - \frac{8}{5}.\frac{a}{e}(p-f).(t-t')$$

$$\text{or } F = f' - \frac{48 \ . \ a.(t-t')}{e} . \frac{p-f'}{30} \quad . \quad . \quad . \quad (D)$$

11. The equation D, applicable for all values of t' above the freezing point, must undergo modification when the stationary temperature of the wet thermometer is below the freezing point, because the caloric given out by the atmosphere brought into contact with the wet bulb, in descending $t - t'$ degrees of temperature, has not only to vaporize a certain quantity of water, but also to liquify a certain quantity of ice.

Allowance is made for this circumstance, by adding to the caloric of elasticity of aqueous vapour the caloric of elasticity of water, that is, by replacing in equation D the quantity e by $(e + e')$.

Doing so we have,

$$F = f' - \frac{48 \,.\, a \,.(t - t')}{e + e'} \cdot \frac{p - f'}{30} \quad . \quad . \quad . \quad (E)$$

12. Let us now replace, in our two last equations (D and E), the quantities a, e, e' by their numerical values. It is sufficiently exact to consider these values as constant, between the ordinary variations of temperature.

According to the best experiments—

$$a = 0{\cdot}267, \quad e = 1129, \quad e' = 135.$$

Making in equations D and E the necessary substitutions, we have,

$$F = f' - 0{\cdot}01135 \,.\, \left\{ t - t' \right\} \cdot \frac{p - f'}{30} \quad . \quad . \quad . \quad (F.)$$

$$F = f' - 0{\cdot}01014 \,.\, \left\{ t - t' \right\} \cdot \frac{p - f'}{30} \quad . \quad . \quad . \quad (G)$$

The formula F is for temperatures above the freezing point.

The formula G is for temperatures below the freezing point.

The quantity $\frac{p - f'}{30}$ being (in certain values of p and f') but little different from unity, may be omitted in calculations requiring no great nicety or exactness; it is however better to retain it.

The foregoing Paper on the Hygrometrical State of the Atmosphere has been submitted to the revision of Doctor Apjohn himself, from whom Mr. Renny received very important assistance in the preparation of it.

Under such circumstances, it is very respectfully submitted to the consideration of the officers of the corps of Royal Engineers, by

H. L. RENNY, M.R.I.A.,
Lieutenant on the Retired List of Royal Engineers.

PAPER VIII.

MEMORANDA ON THE USE OF ASPHALTE,

By MAJOR GENERAL OLDFIELD, K.H.

Having lately heard several complaints of the inefficiency of asphalte in covering buildings, I availed myself of the opportunity afforded me, by a recent visit to Plymouth, to ascertain the state of the asphalte used in covering buildings and lining embrasures under my directions, whilst in that command, as described in my memoranda on the subject, at page 132, vol. 3, Professional Papers.

I have every reason to be satisfied with the efficiency of this valuable material; the casemates in the citadel, which were so damp and wet as to be perfectly uninhabitable, and which were used only as coal stores or for similar purposes, are now impervious to rain, free from damp, and afford accommodation for 286 men, with guard room, defaulter's room, and artillery stores. The Barrack Master writes, "I consider them the best barracks in summer and the most dry in winter,—they require no repairs."

These casemates are floored with asphalte, and this flooring is not considered objectionable by the barrack master; but as the asphalte does not absorb the water spilt by carelessness or used in washing the floors, the barrack master recommends dry rubbing, or that water should be used sparingly and with care. I should not, with these precautions, object to the use of asphalte in floors, as being wet or damp; but so strong is the prejudice against it, that I recommend boarded floors for all barrack rooms.

At the outposts, I could only hear of one instance where the asphalte covering had not been perfectly successful; in this case, I understand that some damp finds its way in at the junction of the arch with the exterior walls of the building, arising, in the opinion of the barrack master, from the supposed omission of a lining of asphalted brickwork to the walls against which the arch abuts.

I visited the magazine-establishment at Bull Point, the roofs of these magazines were covered with asphalte, under the orders of Colonel Ward, R.E., and they have proved impervious to wet and damp during a most trying season. I carefully examined the workmanship on the outside of the roofs,and could not find the smallest crack or defect: it is most creditable to Mr. Corbett, the Clerk of works under whose immediate direction it was carried on.

In the use of asphalte, the greatest care is indispensable in the selection of the material, and in the execution of the work; if these points are attended to no failure need be anticipated; if neglected, failure is certain.

The first embrasure which I caused to be built in asphalted brick work in 1847 has, since the day when it was completed, been in daily use for the morning and evening gun. I found it last month in a perfect state, and am told that it has never required repair. In other embrasures where asphalte has been used, no damage has been sustained from artillery practice from heavy guns with service charges.

J. OLDFIELD,
Major General.

18th June, 1855.

PAPER IX.

Suggestions for the Remedy of Certain Defects in Existing Systems of Fortification.

By CAPTAIN SPENCER WESTMACOTT, Royal Engineers.

That the systems of modern fortification, though founded on sound principles and the data of accumulated experience, still labour under serious defects is generally admitted, and the best that can be arrived at appears to be that in which the nearest compromise can be effected between the objects desired and certain disadvantages inseparably connected with the means for attaining them. From the time of Marshal Vauban, who, adopting the bastion trace received from the early Italian engineers of the close of the fifteenth century, employed it, with various modifications, during the latter half of the seventeenth century, in the construction or improvement of between 300 and 400 fortresses, attention has been directed to discover some trace, equally effective, which shall remedy the defects inherent in the system. In this trace, in order to obtain the flanking defence, an essential addition to the security of every place against assault or escalade, the enceinte enclosure is broken into lines forming angles projecting towards the enemy, while to increase the difficulties of approach and obtain a more extended command over the ground in front, or as it is termed "to develop the attack," the ravelin is added, also offering its salient to the enemy. M. Vauban showed himself perfectly alive to the disadvantage of the saliency of such works and their exposure to enfilade, by inventing the "ricochet fire," through the agency of which three or four guns placed on the prolongation of a work may search into the whole length of the rampart, and subdue or destroy any armament mounted upon it. To lessen this exposure, traverses, bonnettes, or earthen masses, to intercept the passage of shot or shell, were applied, and a circular form has also been suggested for the parapet; but such palliatives produce no material effect or ultimate security against the sure progress of the attack. Another defect, more or less to be found in all existing systems, is that, upon the fire of the place being silenced or sufficiently subdued, the enemy establishing himself near the edge of the ditch, within view and close range of the scarp wall, can batter or destroy by artillery the masonry by which the rampart is supported and rendered inaccessible; and by the same means silencing the fire of the flank intended to protect its corresponding line of defence, proceed to the assault of the place, exposed only to the direct resistance of the rampart attacked. A further disadvantage under which every garrison labours, compared with the assailant, is the facility possessed by the latter of extending his batteries laterally, and thus establishing a fire superior to that of the place. This it has been sought to remedy, by multiplying the batteries of the place vertically, to effect which the placing tiers of guns in masonry towers was advocated about the middle of the last century, and in a measure adopted in some modern fortifications, but against such works the crushing power of the attacking artillery would act with destructive advantage and speedily reduce them to ruin—again, a project has been advanced for obtaining a similar result by placing guns upon a succession of terraces formed entirely of earth ; in this the object intended and the material to be employed, though in themselves no novelty, are good ; but here again in the method pursued a counterbalancing disadvantage presents itself, for, supposing the heavy terraced rampart to resist and support with safety its own weight and the concussion of firing, a serious objection still presents itself in the great mass and object that would be offered for the enemy's fire, which he could not help striking somewhere, and which, though in itself comparatively indestructible, would, by having such terraces, serve as a curtain to catch every shell, and cause it to explode above or roll into the batteries below—thus probably rendering all except the upper tier untenable.

In the Bastion system many improvements and modifications have been introduced or proposed, with more or less success, some being too complicated and expensive for general adoption, even assuming that they answered the purpose intended ; and the French still appear to adhere to the principle of the bastion trace, which is an important testimony to its inherent advantages, and should at once check any hasty criticism or condemnation of a system receiving the sanction of such excellent authority.

In Germany several new traces have been adopted, various both in detail and in the principle employed. In these the saliency of the fronts is reduced ; flanking fire is obtained from caponnières placed below the level of the ground, more or less secure from distant fire ; and by means of masonry towers, covered in front by the ramparts of the work, additional fire is obtained, and, supposing them to be preserved until the final attack, further means of prolonging the resistance are afforded. In some instances the salient angles are so flattened as to bring a battery placed within the ricochet distance of 500 or 600 yards from any face into such a position as to be taken in reverse by the fire from the place, or so close as to be exposed to its grape or musketry—a superior counterbattering fire might negative the former, but both combined would render it impossible to proceed, and thus the question of enfilade is so far practically settled—but works of such limited saliency fail in developing the attack or keeping the enemy at a distance, and projecting ravelins are therefore employed, or strong detached redoubts are placed immediately in front of the work for a similar purpose. In some fortresses the ramparts are also in part secured from enfilade by placing their prolongations on inaccessible ground ; but this may be done in any work, and, as shewn in the examples given in plate I., figures 1, 2 and 3, there is nothing in the nature of the trace employed that prevents their being enfiladed by guns placed on their prolongation, as at E, or their flanks being battered by breaching or counter batteries, as at B. Both in the German and the Bastion systems many examples might be quoted. In other places the enceinte enclosure or continuous rampart has been altogether dispensed with, and formidable independent redoubts, mutually supporting, are substituted—the question of enfilade here ceases almost or altogether. To the powers of resistance by these isolated works great importance is justly attached, and undoubtedly, if proceeded against by ordinary approaches, such would be the case; but when it is considered that these same powers of resistance are mainly limited to what the work itself contains, and that their extent of rampart and armament are greatly inferior to those of the besieger, there are grounds for believing that these works might be made the focus of such a concentrated fire as would possibly reduce the whole in a few hours to a shapeless untenable mass, which must be evacuated or surrendered without waiting for the usual assault, and if so, rendering negative the elaborate system of countermines by which the Prussian and other similar works are surrounded; with an ample supply of artillery and ammunition, this is assumed as possible, notwithstanding examples to the contrary, where the attacking fire appears to have been insufficient.

On the whole, it does not appear that the new German systems, any more than the French improvements of the bastion system, meet the requirements of the case; but without considerable experience and an acquaintance with the particular works themselves, their locality, and the conditions for and under which they have been constructed, it would be presumption to venture an opinion where so much talent has been employed. It is believed that the most recent work combining modern improvements with established principles is that of Rastadt, a fortress of the German confederation, construeted under the direction of officers of the Austrian and Grand Duke of Baden's services, and as the ground presents no very important features, it appears one of the most interesting and powerful examples of artificial fortification, embodying the traces and sections of the Bastion, Carnot's, and the German systems, with powerful independent works and connecting lines; while on some fronts an admirable outline and detail, combining the best parts of the German caponnière system, with valuable additions, understood to be from the designs of General Eberle, of the Austrian Engineers, are employed. Upon an idea suggested on visiting this fortress, part of the following project is founded.

Having, in the previous outline, adverted generally to some of the admitted defects in existing systems of fortification, for which no sufficient remedy has yet been proposed, and the question still remaining an open one, the following project, embodying some suggestions on the subject, has been framed. It has no pretensions to originality beyond the modification of existing systems or works of fortification already constructed, but in these it has appeared practicable, by introducing certain alterations and additions, simple in themselves, to approach, if not secure, some of the objects sought to be attained.

The provisions which it is proposed to make, in order to remedy the defects above adverted to, are as follows:—1st. To produce a trace, in which, by its nature, the body of the place, or general enclosure of a fortress, shall under any circumstances be protected from enfilade; and, where outworks may be employed projecting towards the front of attack, that security shall be afforded against ricochet fire without interfering with their intention or efficiency. 2nd. To secure the flanks and their armament, essential to the final defence, from distant fire or counterbatteries, and from being breached by the direct fire of batteries on the glacis or outworks. 3rd. With less area than in the bastion trace, to enable the garrison to increase their armament so that it shall equal or exceed that which the enemy can bring against it. And 4th. With an extent of rampart nearly identical with the lineal extent of the bastion trace to produce a considerable increase in the area available for defence and in the total space enclosed.

The trace about to be suggested would be suited, by proper arrangements, to wet or dry soil, and as it will not be necessary that the whole front should be in the same plane, and no fixed proportions being essential to its principle, it may be adapted to irregular ground or any particular objects—it may also be applied to extensive or small fronts indifferently, preserving only the requisite range for the armament of the flanks. The construction being simple, it may be assumed that the expense would at least not exceed the cost of an ordinary bastion front of similar extent. The sketches attached will assist in explaining the means by which it is proposed to arrive at the above results.

Supposing that a given site is to be occupied by defensive works, or that a town is to be secured against attack by a continued enclosure, the circuit would be divided into lines of such length as the form of the ground and the range of the armament to be employed, (here taken as under 300 yards for grape or canister shot, for flanking its fronts) would decide ; these exterior lines might vary from 300 to 600 yards. In the annexed example, sketch 4, the method of constructing the fronts of the proposed project is given ; the several steps in the trace are so simple as scarcely to need explanation ; no fixed dimensions are necessary, nor are the proportions adopted arbitrary; within certain wide limits, beyond which practical inconvenience would result, they may be varied according to the nature of ground or capacity desired to be given to any part of the work. The exterior side has been here assumed at 550 yards, and the proportion for the projecting works one-sixth of the exterior side—it is evident that it is not requisite that the same proportion should prevail throughout, adhering only to the principle that at the extremity of each front a " Butt " or mass of earth, sufficiently solid to be indestructible by shot or shell, shall be provided, and that upon some part of this the lines or faces of the work shall be directed, giving such form to the whole trace as shall bring every part under a sufficient flanking fire. 1st. By this arrangement it will appear that the prolongation of the rampart placed upon or behind the line traced, which here represents the scarp wall of the work, would fall upon its projecting ' butt,' which being made somewhat higher than the rampart, would cover the rampart and prevent the alignement being taken. To suppose the prolongation taken, and a ricochet fire employed over this projecting mass, some hundred feet thick, and distant about 400 yards, is an idea not to be entertained—the covered way also, being directed on the salient of this work, is likewise protected—such a trace cannot, therefore, it is conceived, be enfiladed. The "butt" may be scarped, and have such form given to it as may be deemed proper; its flanks obviously forming the proper defence for the main ditch, and when casemated and made sufficiently large, these butts would perform important service as caponnières below, and as bastions above, the ground level : they may be detached or connected with the main work.

2nd. By a reference to the trace it will be seen that there is no position upon the glacis or covered way from whence a battery could be brought to bear, down the ditches, upon the main flanks of the work, nor can the prolongation of the ditch itself be taken up to breach or counterbatter the flanks from a distance : casemate guns may therefore be more securely used in these flanks, and will probably be preserved untouched until the latest period of the siege. As the retired flanks, provided for the ditch of the caponnière bastion, could be enfiladed and breached, they may, being so short, be secured, by keeping them sufficiently below the crest of the curtain rampart, or by placing their guns in blindages ; while the scarp may be protected by throwing it back, and interposing an earthen traverse, as at T, Plate 1, or at T, section C, Plate 2, of which the lower part may be made useful for two or three flanking guns in casemates.

3rd. A glance at the bastion trace *a x y b*, constructed for comparison on the same exterior side, proves that a sufficient saving of space is obtained, without hampering the interior of the work, or interfering with proper freedom of movement within it, to make the addition of cavalier ramparts on the flanks, or throughout the whole front, if required, placing them sufficiently far back, that their weight may not be added to that of the main rampart bearing on the scarp of the ditch, and to allow space between them and the terreplein of the rampart in front, for a ditch, by which shells, striking the face of the cavalier, may be intercepted from rolling upon the work in front, so as to explode out of reach. Being of earth, the cost of these additions would be comparatively inconsiderable, and upon them any augmentation to the general armament, in proportion to the size of the work, may be placed, increasing the fire on particular points, or possibly doubling it throughout. Large fronts would have the advantage of concentrating a heavier fire over the area of the attack than an equal extent of rampart broken into smaller fronts acting obliquely. The necessity for traverses against enfilade fire being avoided, space for additional guns will be gained, still allowing for sufficient splinter-proof traverses, occupying less space.

4th. By a comparison of the projected front with that of the bastion front *a v z b* traced inside in sketch 4, it will be observed that the lineal extent of rampart is nearly identical, but that of the project being principally exterior to the circuit to be fortified, a saving of about 10 acres results on every front over the Bastion Trace with the same exterior side, the works of which encroach upwards of 100 yards within the actual limits of the space enclosed, reducing it to an exterior side of 400 yards only, in place of about 600. The ground thus saved becomes available for further defences, or, if not required for that purpose, may be occupied by bomb-proof barracks and stores, or left for the ordinary civil uses of the locality. To estimate the value of land in England would be difficult; in some places land is obtained at vast expense, in others essential national works have been altogether arrested by the difficulty in obtaining sufficient ground; the importance of this economy in space is therefore evident.

In plate II. the project is further explained; its details admit of an infinite variety of treatment; nearly any section may be adapted to the trace, but it has been endeavoured throughout fully to preserve the ordinary conditions, by providing scarps sufficiently high to be secure from escalade, and covering all masonry from direct fire, as well as from the fire of artillery at low angles over an intervening work. In completing the enclosure, or body of the place, a section has been assumed, giving a scarp of such height as would require a ladder 40 feet long to scale it, assumed from its unwieldiness and the difficulty of carrying and raising it under fire, to preclude the possibility of escalade: the revetment with the "chemin des rondes," approved by Vauban, is here adopted, not only for its general advantages, but also that being loop-holed, musketry, which from the powerful effect of the new arm cannot be too greatly multiplied, may be freely employed. Any inconvenience to be expected from the arresting of shells against the face of the rampart in rear may be reduced by forming "shell ditches" where the space admits, in exposed positions, and towards the latter part of the siege, making temporary blindages. The command of the main rampart would be regulated by that of the works, if any, in its front, and the crest of the retired flanks, if not otherwise protected, may be placed somewhat lower than that of the adjoining rampart, or perhaps provided with blinded cover. A double fire may be obtained from these flanks by adding a cavalier in rear, with a shell ditch at the foot of its slope, as a security to the troops employed in front. They might also afford bomb proof cover for guards or other purposes.

Considering the projected trace irrespective of any outworks that may be added, it would appear that the salient of the caponnière-bastion offers the most vulnerable point of attack; difficulties may therefore be multiplied at this point by various methods. Three plans are shewn, two simple but perhaps sufficient, the third strengthening the work by cutting off the salient by a ditch, x, section B B B, fifteen yards broad, with a scarp similar to the body of the place, flanked by a caponnière; with the inner ditch y, cutting off all communication with the main work, except by access secured to the garrison, and this flanked at either end by galleries in the main work--The whole angle of the main work might finally be isolated, as shewn in plan and section B, by a ditch and scarp wall, or by a simple entrenchment when occasion arose. These arrangements would necessarily increase the expense, and might be added or not, or partially employed. A rampart across the middle, armed with heavy long-range guns, would afford a valuable fire on the approaches to the salient. In respect to the "butt," or mass of earth at the salient, it might simply be a solid mound, or if constructed roomy enough, and armed with guns in a "blindage," would play an important part until silenced, and when reduced to a mere heap, would still answer its original intention as a "butt," being from 50 to 100 feet thick, diagonally.

Outworks may be added, but they do not necessarily form part of the trace. The importance, however, of developing the attack has not been overlooked. A work enclosed by straight, circular, or any continuous lines, opposing but one obstacle to an enemy, and presenting many points equally vulnerable, would be open to attack throughout, enabling the besieger to apply his more numerous forces over an extended front, in place of compelling his attention to particular points, where a confined space would place the forces actually engaged on a footing nearer equality. To remedy this, Marshal Vauban, in the trace which Cormontaigne and others have improved, employed the projecting ravelin, in which the radical defect of exposure to enfilade fire is prominently displayed, and this, though in a less degree, is also preserved in many of the German works; in the latter a detached redoubt is sometimes thrown out to answer the same object, but these confined unconnected works appear objectionable, for the reasons before given in speaking of the isolated detached redoubts, though they are doubtless highly important if viewed only as auxiliaries.

On the whole, so many advantages appear to be presented by the capacity, the capabilities for successful resistance from each point, and the facilities for giving close support, afforded by the ravelin, that it is desirable, if possible, to retain it, providing the means for reducing, if not remedying, its exposure to enfilade, and the method proposed for effecting this will be seen in the plan. The flank adjacent to that of the caponnière bastion being taken for the flank of the ravelin, and provided with a low casemate, as previously described for the adjoining portion, the face of the ravelin is projected at right angles to it. Such a work could, of course, be enfiladed along its whole extent; to prevent this, therefore, and to cover the ravelin and its redoubt, a "salient butt," somewhat similar to that in the main work, is repeated, its mass being isolated from the rest of the work by a ditch of any given width, flanked by a casemated fire from the redoubt of the ravelin: the scarp of the ravelin would be continued, capped with angular coping to prevent access on the top. As the space occupied by this "butt" would be too valuable to leave only as a mass of earth, it is proposed to arm its salient with four 8 or 10 inch long-range guns, probably in open embrasures, as the heavy charges would cause inconvenience if in a confined space, while its retired flanks would carry three or four guns each, under blinded cover, ranging laterally over the whole space in front of the caponnière bastions. It is presumed that the salient guns will sooner or later be silenced, and the "butt" reduced to a mere heap; but it will still exist and answer its purpose, while it is not evident that the fire of the retired faces or shoulders will be destroyed, as they cannot be seen directly, within any practicable range, and the "butt" protects them by about 100 feet of solid earth towards their ends—thus preserving a most important fire to the latest period of the siege. If this "salient butt" be assaulted and carried, it is presumed that, being seen into by the redoubt and the body of the place, an enemy could not hold it or establish himself upon so confined a space, commanded inside and out from the main work. See enlarged plan, plate 3.

It may be objected that this "butt" masks, in a measure, the fire from the place; this is met by directing its shoulder-flanks upon the centre of the curtain, and at right angles to it, thus preserving the entire direct fire of each curtain, and allowing, as will be seen by calculating the extent of parapet bearing upon the ground in its front, the fire of 50 pieces to be concentrated from the main work in this direction, independent of mortars. As the covered way of the ravelin would be exposed to enfilade it might be dispensed with, and a countersloped glacis formed to facilitate sorties from the ditch; or if, to preserve the great advantages of such an addition, it be used, traverses may be provided, as traced in the plan, directed upon the main curtain, and subject to a fire from thence over the ravelin with reduced charges.

A redoubt in the ravelin may be added, protected from enfilade by the same "butt," its gorge secured by a bombproof casemate, loop-holed, and commanding the main ditch, and its own ditch flanked by casemated guns in the main scarp, or by caponnières placed across its ditch.

The employment of the "butt" of earth described above, as a receptacle for shot or shell which are intended for enfilading the ravelin, is similar in intention to the cavalier proposed by General Dufour—with the latter, however, it is submitted that it appears possible very nearly to ascertain the direction of the faces, and thus except close to the cavalier, to bring a fire to bear upon them, while the redoubt within is left altogether uncovered—his cavalier is, moreover, a dead mass, and takes no part, as an active element, in the defence, except by its musketry upon the besieger's saps and approaches.

In the re-entering places of arms, redoubts (P) may be traced, secured from enfilade by directing their faces on the salient butt, and the salients of the covered way of the caponnière respectively. The commands of the different works are supposed to vary from 10 to 6 feet over that in front, whether guns, howitzers, or mortars be employed. With regard to the second rampart or inner line of defence, its addition would be optional—a simple polygonal trace is here adopted, flanked by ordinary caponnières. This interior line of works stands on ground identical with that which would be occupied by the curtains of the Bastion Trace constructed on the same exterior side—thus gaining a double line of defence upon the same area, or, if confined to the first or enceinte enclosure, saving a space of ten acres on each front, while maintaining an equal lineal extent of defensible works. The whole or a portion of this, or of the main outer enclosure, would afford cover for bombproof barracks, stores, or magazines, formed beneath the ramparts.

Facilities for internal communication, and access to the outworks, or for sorties, would be required, and gates and sally-ports formed where convenient—in exposed places ramps of earth, or where the space was limited, steps would be provided, and their entrances and course placed under traverses, or in the thickness of the parapets and ramparts, to preserve them from vertical fire—it is unnecessary, however, to enter into details presenting no novelty, and which do not bear upon the particular points to which this paper is directed.

In the above outline of a modified trace for the front of a fortress, or for an enceinte enclosure, with outworks that might be applied to it, it has been endeavoured to embody as proposed—protection against enfilade fire, security to the flanks and their armament, protection to the main scarp, economy in space, and power of increasing the general armament of the fortress, so as to equal or exceed any number of guns that could probably be brought against it.

The following details will further illustrate the latter point, shewing by a comparative statement the armament for one front of the bastion trace, and that capable of being mounted on the projected front, allowing in the latter an average of 30 feet to each piece, including traverses, and taking for the former the armament attributed to Noizet's improved bastion system, considering both in the first instance irrespective of outworks :—

Bastion Trace.

Salients of two bastions.	2
Two faces of bastions	24
Two flanks	16
The curtain	20
Total in the body of the place	62

Proposed Modified Trace.

Salients of two caponnière bastions	2
Two faces of ditto	6
Two half-fronts ditto	6
Casemated flanks of ditto	20
Main rampart or enceinte	52
Casemated retired flanks	8
Casemated flanks to the redoubt of ravelin.	4
Total in the body of the place	98

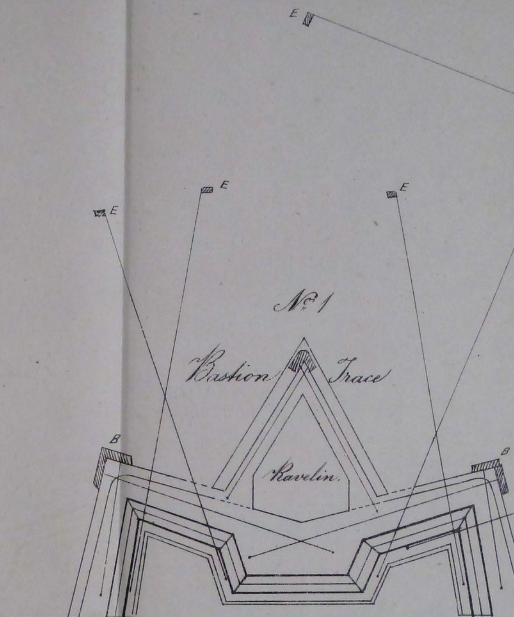
This gives a total of 98 pieces on the enceinte enclosure, exclusive of mortars. To this may be added the whole extent backed by a cavalier-rampart, mounting 40 additional guns, at the same rate, or a total of 138 pieces in the body of the place alone.

If outworks be employed, a portion of the fire from the central curtain, about 18 pieces, may be in a measure obstructed, but these will yet, at an elevation of about 1¼ degrees, act directly against the first parallel, distant from 800 to 900 yards, the shot passing 20 feet clear of the crest of the ravelin, or 10 feet clear at a point blank range of 400 yards; while by depressing the guns, their shot would just clear the works in front and pass along the slope of the glacis, about 2 feet from its crest; taking, therefore, the outworks in addition to the body of the place, and omitting the interior or second line of defences, the grand total of guns capable of being mounted on each front will appear as follows;—

Body of place	98
Cavalier rampart	40
Ravelin	30
Redoubt of ditto	15
Salient or butt of ravelin	10
Places of arms	14
	207
Mortars and coehorns	40
Total in each front of Modified Trace	247

The above would be exclusive of collateral fire over the front of attack from adjacent works, and it is conceived that, unless the besiegers were placed in unusually favourable circumstances as to transport, it would be impossible to convey and maintain a siege train of sufficient magnitude to cope with the direct and supporting fire of fronts so armed, and against which the advantages of a ricochet or enfilade fire would not avail much.

Having thus described the objects and results of the projected trace, there yet remain some further points bearing upon the subject; but before closing this portion, it may appear an omission not to observe that if the assumed difficulty of approaching a place thus fortified and reducing it by the fire of artillery be realized, the enemy would, if the ground permitted, resort to mining. This, it is obvious, may apply to any system, having nothing to do with the trace, and in such operations, tedious in the extreme, the besieged being previously prepared, can act with equal or greater power than the larger forces of the besieger, which would remain inactive while a small fraction of either party pursued a dangerous and uncertain subterranean warfare: this method of attack would therefore, granting it were successful, occupy many weeks, and be manifestly to the advantage of the garrison.


E
E
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E
No. 1
Bastion Trace
B
Ravelin.
B

PAPER X.

Record of the Demolition of a Trench-Cavalier by Five Charges Exploded Simultaneously by Means of the Voltaic Battery,

At the Royal Engineer Establishment at Chatham, on the 31st of October, 1855.

Communicated by COLONEL SANDHAM, R.E., Director.

A trench-cavalier was constructed in front of the left face of the ravelin which covers the curtain connecting the Duke of Cumberland's and Prince Frederick's bastions.

The soil on which it was situated was loose and sandy, and contained very few stones, and the ground has a slope to the rear of about 1 in 10½.

The cavalier consisted of two faces, 100 feet and 50 feet in length respectively; the longer face being nearly parallel to the ditch of the ravelin, and the shorter face making an angle of about 125° with the other. The parapet was raised 11 feet above the surface of the ground, and was revetted with 3 tiers of gabions, surmounted by 4 rows of sand bags forming loop-holes: the trench in rear was 3 feet deep, and it was 26 feet wide at the longer side, and 29 feet wide at the shorter side.

From the bottom of the ditch of the ravelin, which is 9 feet deep, two descending galleries, 4 feet 6 inches by 3 feet, were driven parallel to the surface of the ground; that on the right, or No. 1, was directed to a point 42 feet from the extremity of the long face of the cavalier, and that on the left, or No. 2, was parallel to the former and 56 feet from it, but a portion 33 feet long, at its extremity, was horizontal; these galleries extended to points directly below the crest of the work: from the end of No. 1, two branches, 3 feet 6 inches × 2 feet 6 inches, were driven at right angles to it, that to the right to a point of 24 feet from it, with a slope of 1 in 6, and that to the left to a distance of 16 feet, with a slope of 1 in 4. (See Plate,)

From the end of No. 2 two branches were driven horizontally, that to the left to a point 5 feet from its extremity, and that to the right to a point 15 feet from it.

It was only intended to destroy the longer face of the cavalier, as the other would thereby be exposed to the fire of the ravelin, and rendered untenable, and 5 charges were placed in the branches, (four at their ends and one at a point in the branch 2 ft. beyond the right side of No. 1) all were placed at the level of the roofs of the branches, except the last mentioned charge; which was, of course, above the latter, as the branches of No. 1 were inclined.

The lines of least resistance of all the charges were 8 feet long, and the charges, if calculated by the formula $\frac{1}{11} l^3$, would have been 46 lbs. each, but all were 40 lbs., excepting that at the salient angle, which was 50 lbs.

The extremity of No. 2 was too near the surface, which caused inconvenience from the earth falling in.

The charges were placed in cubical wooden boxes, 11½ inches square in the clear.

All the branches were tamped, and gallery No. 1 was also tamped for a distance of 10 feet, and No. 2, 8 feet, the tamping consisting of the earth originally taken out

The reliefs were of 6 hours each, and fresh men were sent at each relief, the rate of progress of excavation was about 1¼ feet per hour.

The time occupied in excavating	the galleries	was	94 hours.
,, ,, tamping	,,		34 ,,
	Total	. .	128 hours.

The results of the explosion were, that

	lbs.		ft. ft.		
the charge	A of 50	produced a crater	22 × 19,	leaving no cover.	
,,	B of 40	,,	19 × 18,	leaving cover	5 ft. in height.
,,	C of 40	,,	16 × 15	,,	3 ft. 9 in. ,,
,,	D of 40	,,	11 × 9	,,	5 ft. 3 in. ,,
,,	E of 40	,,	18·6 × 11	,,	5 ft. ,,

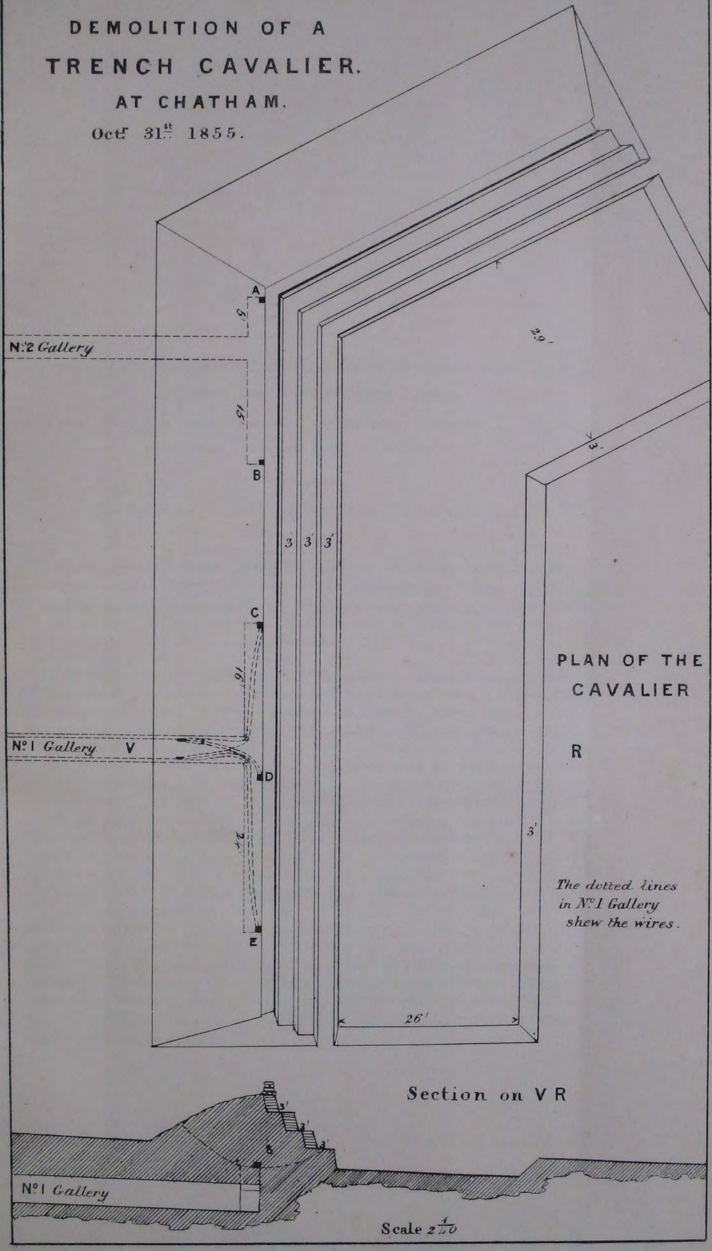
The charges were fired with a Grove's battery of 12 cells, as described by Captain Ward, R.E., in Vol. IV., New Series, page 135; the main conducting wires, which extended to the tamping of each gallery, being the same as were used at Seaford, and consisting of 3 strands. (See Vol. 1., page 81, New Series.)

The wires connecting the bursting charges with the main conductors were covered with gutta percha, and weighed about 240 grains per yard.

The advantages and disadvantages of the mode employed in arranging the wires are described in Vol. IV., page 161, and will be evident from the accompanying diagrams; but here one battery was made use of to fire two independent sets of charges simultaneously, and it was intended, if this effect had not taken place, to apply the whole force of the battery first to one set and then to the other, which might have readily been done almost instantaneously, by momentarily removing one of the conducting wires from the mercury cup which connected it with the battery.

DEMOLITION OF A TRENCH CAVALIER. AT CHATHAM.

Octr. 31st. 1855.



PAPER XI.

Records of Experimental Practice against Wrought and Cast Iron Columns and Wrought Iron Plates,

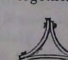
Carried on under the Direction of Colonel Colquhoun, R.A., and Colonel Sandham, R.E., at Woolwich.

Communicated by COLONEL SANDHAM, R.E.

Notes of Experimental Practice against Wrought Iron Plates of Lowmoor Iron, 4 Feet × 5 Feet, and ⅝-inch Thick, Placed Obliquely to the Line of Fire at Various Angles. (See No. 2 Table.)

These experiments were commenced in July, 1846, with an 8-inch iron gun of 65 cwt., using 56 pr. hollow shot; and after two days' practice, a 32 pounder of 56 cwt. was substituted. Two rounds were fired from the former against a double iron plate, clamped against a wooden gun-carriage loaded with 3 cwt. of pig iron, the inclination of the line of fire to the plane of these plates being 10°, and the charge 4 lbs.; one round was also fired at an inclination of 15°, but no results were obtained, as this shot, hitting the plates where they were unsupported by the gun-carriage, passed quite through them. One shot, at an angle of incidence of 10°, struck the plates where they were supported, and deflected, but did not break. After this the 32 pounder of 56 cwt. was alone used, against single plates of iron backed by blocks of granite, firing at angles of incidence of from 10° to 30°, and increasing the angle 2½° each time. The experiments were carried on till September, 1846, were resumed in August, 1847, and were discontinued only for want of blocks of granite or other stone. When the last block of granite was shattered, a mass of oak (4′ × 4′ × 4′) was put together as a support for the plate which was placed at an angle of incidence of 30°; the shot fired with a charge of 4 lbs. passed through the plate, and through the whole mass of timber, and completely destroyed it. The shot in almost all these experiments were broken on striking the plate, and deflected, producing showers of small splinters which would have been very destructive to men. The second table will bring the effects of the fire at each angle at once before the eye.

No. 1. TABLE of Experimental Practice

Day's practice.	Date.	No. of effective rounds.	Nature of Gun.	Nature of shot.	Charge.	Elevation.	Range in yards	Nature of column.	Plans showing columns, and how disposed.
1st.	1846. 30thJune	1	8 in. of 65 cwt.	56 lbs. hollow. naval.	10 lbs.	POINT BLANK.	240	Cast iron hollow, 10 feet high, 9 inches in diameter and 1 inch thick. 	1st round. 1o 2o 5o 3o 4o
—	..	2	do.	....	do.		240		2nd round. o2 o5 o3 o4
2nd.	6th July	1	8 in. of 65 cwt.	56 lb. hollow, naval.	10 lbs		240	Wrought iron plates $\frac{5}{8}''$ thick, cylindrical, riveted together at the joints by iron straps. 10 feet high, 9 inches in diameter, the cylinders in 5 feet lengths.	o1 o2 o4 o3 o5
—	..	2	do.	do.	do.		do.		
—	..	3	do.	do.	do.		do.		
—	..	4	do.	do.	do.		do.		
—	..	5	do.	do.	do.		do.		
3rd.	7th July	1	32-pr. of 56 cwt.	Solid.	10 lbs.		240	Wrought iron, as on second day,	o1 o2 o3
—	..	2	do.	....	do		do.		
4th.	8th July	1	32 pr. of 56 cwt.	Solid.	8 lbs.		240	Wrought $\frac{5}{8}''$ iron, flanged and riveted together  in this form.	Δ1 Δ2 Δ5 Δ3 Δ4
—	..	2	do.	do.	..		do.		
—	..	3	do.	do.	..		do.		
—	..	4	do.	do.	..		do.		
—	..	5	do.	do.	..		do.		
—	..	6	do.	do.	8 lbs.		do.		
—	..	7	do.	do.	..		do.		
—	..	8	do.	do.	..		do.		
—	..	9	do.	do.	..		do.		
—	..	10	do.	do.	..		do.		
5th.	15th July	1	32-pr. of 56 cwt.	Solid.	4 lbs.		240	One cylindrical column between two flanged ditto, all wrought iron.	1 2 3 ▷O◁ Δ4
—	..	2	do.	do.	do.		do.		
—	..	3	do.	do.	do.		do.		
—	..	4	do.	do.	do.		do.		
—	..	5	do.	do.	do.		do.		

RESULTS.
Column No. 1 struck at 2 ft. 4½ in. from ground and broken into 2 pieces, but not displaced. (Shot broke.)
Column No. 1 was removed. Column No. 2 struck at 1 ft. 10 in. from the ground and broken into 3 pieces, two of which were on the ground. Column No. 3 also struck and broken into 3 pieces, all lying on the ground. (Shot broke.)
Column No. 1 pierced through back and front, but still supported the top weight. Col. 2 pierced through front only.
Col. 1 pierced through again back and front, but still supported the top weight. Col. 2 was bent in the centre at a joint.
Column No. 1 was again grazed, producing no further effect; graze ½ in. deep.
Column No. 1 was again grazed, producing no further effect; graze 1½ in. deep.
Column No. 1 was again grazed bending it a little, but it still supported the top weight; graze 3½ in. deep.
Column No. 1 struck at the side, 2 ft. 9½ in. from ground, leaving 14½ inches only of circumference of column, which still supported the top weight. No. 2 Column was merely grazed by the splinters of the broken shot.
Column No. 1 was pierced through and through; the front only shewed a hole the size of the shot, but the back was much torn away; the column was a little bent, but supported the top weight. No. 2 column was also struck and pierced through and through, the shot tearing away much of the column both back and front, which was also bent; it however bore the top weight.
Cols. 1, 2, and 3 were grazed on the left flange, cutting out 1¾ in. from No. 1. 2 ft. 10″ from No. 2, and 1¾ in. from No. 3.
Do. Do. doing no serious mischief to any of the columns.
Cols. 2 and 3 were grazed on the left flange, cutting out 1⅝″ from No. 2, and $3\frac{3}{10}$″ from No. 3, doing little harm.
Col. No. 1 was hit exactly in centre, divided into two and knocked down. Nos. 2 and 3 were grazed by splinters.
(Col. No. 1 was removed.) 2 was not hit. 3 was grazed on left flange, cutting out 1¾ in. but doing no other damage.
Col. No. 2 was grazed on right flange, cutting it out to half the diameter of the shot, and doing no other damage.
Col. No. 2 was again grazed on left flange, so was No. 3, doing no serious injury.
Cols. Nos. 2 and 3 ditto ditto
Ditto ditto the columns still supported the top weight.
No. 2 column was hit in the centre, and cut in two, and fell to the ground; No. 3 but slightly grazed.
No. 1 flanged pile was knocked down. No. 2 cylindrical pile was pierced through and through, leaving 14½ in. of its circumference only.
Col. No. 1 was struck on the left flange, and much torn at the rear.
Cols. 2 & 3 were both struck where they touched each other, 3″ of each cut away; and 3 forced 1 ft. 6 in. to right at base.
Col. No. 4, flanged pile, was struck, and the rebound of the shot knocked down column No. 3.
Col. No. 2 was pierced in front near top, and the back of the column was much torn, but the shot had not sufficient velocity to go through and through, and it was found inside the column.

No. 2. TABLE of Experimental Practice carried on against Wrought Iron Plates,

Day's practice.	Date.	No. of effective rounds.	Nature of gun.	Nature of shot.	Charge.	Elevation.	Range in yards	Nature and number of iron plates.	Angle between the plates and the line of fire.
6th.	1846. 20th July.	1	8 in. 65 cwt.	56 lbs. hollow	4 lbs.	POINT BLANK.	100	2 plates placed close to each other.	10°
7th.	3rd August.	1	8 in. 65 cwt.	56 lbs. hollow	4 lbs.		100	2 plates	10°
—	......	2	....	....	..		..	....	15°
8th.	4th August.	1	32 pr 56 cwt.	32 lbs. solid.	1		100	1 plate.	10°
—	......	2	....	....	2		..	....	do.
—	......	3	....	....	4		..	....	do.
—	......	4	....	....	4		..	....	do.
—	......	5	......	....	4		..	....	do.
9th.	8th August.	1	32 pr. 56 cwt.	32 lbs. solid.	4		100	1 plate.	10°
—	......	2	....	....	4		..	....	do.
—	......	3	....	....	4		..	....	do.
10th.	26th August	1	32 pr. 56 cwt.	32 lbs. solid.	10		100	1 plate.	10°
—	......	2	do.	do.	1		..	......	12½°
—	......	3	do.	do.	2		..	....	12½°
—	......	4	do.	do.	4		..	....	12½°
—	......	5	do.	do.	10		..	....	12½°
—	......	6	do.	do.	2		..	....	15°
—	......	7	do.	do.	4		..	....	15°
—	......	8	do.	do.	4		..	....	15°
11th.	3rd September	1	32 pr. 56 cwt.	32 lbs. solid.	4		100	1 plate.	15°
—	......	2	....	......	10		..	....	15°
—	......	3	....	....	4		..	....	17½°
—	......	4	....	....	4		..	....	17½°
—	......	5	......	.....	10		..	......	17½°
12th.	4th September	1	32 pr. 56 cwt.	32 lbs. solid.	4		100	1 new plate.	20°
—	......	2	....	....	10		do.	1 new plate.	20°
—	......	3	....	....	4		do.	1 new plate.	22½°
—	......	4	....	....	10		do.	1 new plate.	22½°
13th.	1847 27th August.	1	32 pr. 56 cwt.	32 lbs. solid,	4		100	1 new plate.	25°
—	......	2	....	....	10		..	....	25°
—	......	3	......	....	2		..	1 new plate.	25°
—	......	4	......	......	2		..	....	25°
—	......	5	....	....	2		..	....	27°
—	......	6	....	....	2		..	....	27°
14th.	30th August.	1	32 pr. 56 cwt.	32 lbs. solid.	4		100	1 new plate.	27°
—	......	2	....	......	10		..	....	27°
15th.	4th September	1	32 pr. 56 cwt.	3 lbs. solid.	2		100	1 new plate, supported by a mass of oak about 4 ft. cube.	30°
—	......	2	....	....	10		..		30°
—	......	3	....	....	4		..		30°
—	......	4	....	....	4		..		30°

…feet by 5 feet, and $\frac{5}{8}$ inch thick, placed obliquely to the line of fire.

…of …ive …ds.	REMARKS.
	The plates were clamped against the cheek of a ship gun carriage, mounted on a traversing platform ; the shot struck the surface of the plates where they were not supported by the carriage cheek, and cut a piece out; it did not deflect horizontally, and rose over the butt. The carriage was loaded with pigs of ballast, weighing 3 cwt.
1	Both plates fell to the ground, and both were indented by the shot, which deflected $6\frac{1}{2}$°.
2	Shot struck the edge of the plate and passed through it (the plates were fixed as on the 6th day.)
1	Shot grazed and deflected 4° ; indentation $\frac{1}{2}$ inch deep.
2	Shot grazed and deflected 4° ; cracking the plate (indentation $2\frac{3}{4}$ inches.)
3	Shot struck the edge of the plate, and tore it away, deflecting upwards.
4	Shot grazed the further edge of the plate. (Indentation $\frac{1}{4}$ inch.)
5	Shot struck the further edge of the plate again where unsupported, and took out a piece of it.
1	Shot passed through the edge of the plate and cheek of carriage, and was thrown back 6 ft. by striking an iron bolt.
2	This shot went in amongst the pigs of iron and broke into small pieces, breaking several of the pigs.
3	The shot struck the plate in the centre, at an unsupported spot, it opened the plate, but the shot deflected
1	Plate was attached to a granite block, 4 ft. 11 in. by 4 ft. by 3 ft 5 in , weight 13 cwt. 3 qrs. 27 lbs., mounted on the slide platform. Shot grazed and broke, deflecting $4\frac{1}{2}$°.
2	Shot hit the edge of the plate and stone, the shot fell and the stone was broken.
3	Shot grazed and broke, the plate was intended $\frac{1}{4}$ of an inch deep.
4	Shot grazed the further edge of the plate and cracked it through.
5	Shot grazed at the centre of the plate and broke into many pieces, deflecting $17\frac{1}{2}$° in a circle, (indent. in plate 1 in.)
6	Shot grazed at the centre of plate and broke into 8 or 10 pieces deflecting in a circle (indentation $\frac{3}{8}$ in.)
7	Shot struck the near edge of plate and stone, indenting the stone 3 in. deep : it broke and deflected in a circle.
8	Shot struck the block of granite and carried away the plate, which was much shattered by the stone at back.
1	The shot struck in centre of plate and broke, deflecting $13\frac{1}{2}$°. (Plate indented $\frac{7}{10}$ in.)
2	Ditto ditto 13°. (Indentation $\frac{3}{4}$-in.)
3	Shot struck the further edge of the plate which it carried away ; it neither broke nor deflected.
4	Shot struck centre of the plate, broke and deflected $30\frac{1}{4}$° in a circle. (Plate indented $\frac{3}{4}$ in.)
5	Ditto ditto 30° ditto $\frac{8}{10}$ in.
1	Shot grazed centre of plate and broke, deflecting 7° in a circle 3 ft. in diameter at a distance of 10 ft. from the point of impact, (indent $\frac{1}{2}$ in.) A piece of granite 1 ft. 6 in. by 1 ft. 6 in. by 9 in. was broken off.
2	Ditto $21\frac{1}{2}$° in a circle 3 ft. in diameter (indent $1\frac{1}{4}$ in.) Plate moved forward $\frac{1}{2}$ in.
3	Ditto 18° in a circle $2\frac{1}{2}$ ft. in diameter (indent 1 in.), Plate moved forward 1 in.
4	Ditto $18\frac{1}{2}$ in a circle 5 ft. in diameter (indent $1\frac{1}{4}$ in.). Plate moved forward $3\frac{1}{2}$ in.
1	Shot hit centre of plate and broke, deflecting 21° in a circle 3 ft. 6 in. diameter.
2	Ditto the pieces of the shot got behind the plate and carried it away 10 ft., breaking away the screen for marking
3	Shot struck top edge of plate, deflected upwards against a beam, and then downwards into the butt, [deflections upon·
4	Shot struck and broke into 7 large pieces, deflecting $16\frac{1}{2}$°.
5	Shot hit edge of plate and fell unbroken.
6	Shot hit centre of plate and broke into 6 large pieces, deflecting $21\frac{1}{4}$°.
1	Shot broke into 2 pieces, hit centre of plate which was well supported by the stone, deflected 21°, and formed a hole 1 inch in width.
2	Shot broke into 4 large pieces and numberless small ones, deflected 11°, and tore away about 9 in. by $6\frac{1}{4}$ in. of the plate
1	Shot did not break, it fell out of the bed which it made for itself in the plate, about half its diameter in depth.
2	Shot broke, some pieces went through the plate and 3 feet into the timber support, and some pieces deflected.
3	Shot went into the hole made by the 1st shot, and through all the timber.
4	Shot broke and deflected, 2 pieces were 2 ft. 1 in. apart ; one half of the shot went through plate and timber, upsetting the block completely.

PAPER XII.

Description of a Revolving Loophole Constructed of Metal, invented by Mr. HANLON, Clerk of Works, Royal Engineer Department,

Accompanied by a Record and Report of Trials made with it at the Royal Engineer Establishment at Chatham.

Description of the Revolving Loophole.

The revolving loophole consists of three parts; the centre part A (figs. 1, 3 and 7), is a solid metal cylinder which revolves inside a cylindrical box or casing B, which is also constructed of metal, and is formed of two parts having lateral flanges or plates C, C, which are secured to each other by means of the screws D, D. The cylindrical box is pierced with openings, as shewn in figs. 1 and 3, and the enclosed cylinder is also perforated for the passage of the musket or rifle, the aperture outside being made only just large enough to leave room for the free passage of the muzzle and ramrod, with a sufficient space at the top for the sight and aim.

The musket or rifle, being passed through the loophole in the direction *a b* fig. 3, a command is obtained of every object within range in the prolongation of that line, and being used as a lever, laterally, the barrel gives motion to the cylinder A, so as to bring the line of fire into the direction of the lines *a c*, or *a d*, which gives a sector of 60° horizontally, under perfect command. The elevation and depression of the line of fire are limited by the inward splay of the loophole, as shewn in fig. 7. The handle and lever at E, fig. 1, regulate the movement of the cylinder A thus; when the lever is moved so as to be in contact with the check at *f*, the point *b* will have moved to *d*, and when it is required to close the loophole, the cylinder is raised by means of the handle until the lever passes over the check at *f*, and being moved round, it drops into the notch at *g*, in which position the aperture *h i* will be at right angles to *a b*.

The distance between the dotted lines at *p*, fig. 7, shews the space between the enclosed cylinder and the top of the casing, for the purpose of raising the cylinder in the act of closing the loophole, as above explained.

These loopholes may be made of cast-iron galvanized, or of gun metal, and the inside of the casing of cast-iron, with, in either case, gun metal screws, handle and lever. Gun metal is to be preferred in situations much exposed to musketry fire, as it is not so liable to fracture and splinter as cast-iron.

With the view to economy, the revolving cylinder may be made of malleable iron, galvanized, with gun metal in the outside, and cast-iron in the inside portions of the casing; and it is probable that the whole might be manufactured from malleable iron, at a cost much under that of gun metal, by the use of machinery adapted to the formation of the several parts.

The screw holes *v*, *v*, are intended to be countersunk on both sides, so as to afford facility for fixing the loophole from either side of the planking, &c., as circumstances may render necessary.

Extracts from the Description of the Modes of Applying the Revolving Loopholes invented by Mr. Hanlon.

Fig. 2, in the accompanying plate, shews the adaptation of the revolving loophole to gates, doors, or shutters. In these examples it is assumed that the framing is prepared to receive the loophole; and this may be made of sufficient thickness, according to the nature of the timber, to be musket ball-proof; or if more expedient, the doors, &c , may be of the ordinary thickness, and be lined with plate-iron of sufficient thickness to insure that object.

Figs. 1 and 3 shew how the loopholes can be fitted to existing doors, gates, shutters, &c., by cutting through the panels, and inserting the loopholes either inside or outside, as may be most convenient: in such cases the doors, &c., may be rendered musket-ball-proof by either of the modes described in the preceding paragraph.

These loopholes may also be adapted to stockades or similar works, such as block houses; and the cheeks of the openings formed for them between two logs may be lined with plate-iron, to render them musket proof, or may be strengthened by cleats or ribbands, spiked or trenailed to the logs inside.

Figs. 4, 5, and 6 shew the application of the revolving loophole in the formation of shields for placing on the tops of walls, parapets, &c., not exposed to the fire of artillery. These shields may be made of oak or elm, in lengths of 3 feet, so that when set up they may form a musket-proof cover, and if thought desirable, may be backed up with earth or sod work outside, as may seem most expedient These shields are so devised as to be easily put together with dowels, and wrought-iron screws with rings. When detached they will occupy little space, and therefore, for the use of forts or batteries, may be kept in store until required to be brought into requisition for the defence of the place.

Figs. 8, 9, and 10 shew the details of a shield of galvanized plate-iron fitted with the revolving loophole, which being more durable than wood, may be considered preferable for the purpose named in the last paragraph. A plank of any thickness may be laid down on the parapet, to which the bottom of the shield may be spiked or screwed. When placed in position, edge to edge, they would give a distance of 2 feet 4 inches from centre to centre of the loopholes, and if required to be 3 feet from centre to centre (which is the usual distance for musketry), the intervening space of 8 inches may be filled up, either with sod work or sand bags, and if required to be permanently fixed on the parapet of a work, the outside might be backed up with earth or sod work, and a log or billet placed at *i*, fig. 10, will retain the earth or sod work for forming the slope over the top. The curved form given to the sides and top of the shield is suggested as being calculated to deflect towards the flanks the musket or rifle balls fired against them, and which it is conceived would render them of much value as cover for riflemen in detached and commanding positions.

Fig. 7 shews the adaptation of the revolving loophole to brick walls; the details are given for a $1\frac{1}{2}$ brick wall, but it is obvious that it can be adapted with equal facility to walls of a greater or less thickness, and it may also with great facility be inserted in walls of masonry or in thick wood-work, such as the walls of block houses.

These loopholes, if fitted in a light framework of oak or elm, would it is thought, be portable enough to be carried about and used in rifle pits or trenches, in which, being flanked on each side, and covered at top with sandbags, as in the ordinary sandbag loopholes, almost perfect security would be obtained against the enemy's sharpshooters, whilst at the same time the consciousness of being so protected would give so much confidence to the men as to enable them to direct a steady and certain fire against any object, whether still or in motion, within range of their weapons, and consequently it is to be expected that the casualties from the enemy's fire would be considerably diminished, at the same time that those of the enemy would be increased in a far greater proportion.

As mere ventilators which can be opened and shut at pleasure, they will, it is considered, be of much value in many respects, particularly where it is desired to combine that object with defence, in public buildings, such as barracks, guard rooms, caponiers, &c.

T. F. HANLON,

Clerk of Works.

Halifax, Nova Scotia, February 1st, 1855.

Royal Engineer Office,

Halifax, N.S., 12th February, 1855.

SIR,

In designing the general arrangement and details of the new military prison, proposed to be erected at this place, I found it necessary to consider how I could best contrive the loopholes for musketry in the flanks and other parts of the building, so as to combine the advantages of outward inspection and ventilation with that of defence, in the simplest form, and at the least possible cost.

From an examination of the accompanying plan, and models marked A and B respectively, I trust that you will have reason to be satisfied that I have been successful in effecting the object in view.

I beg to be permitted to observe that, in a military point of view, as a loophole for musketry or rifle service, it appears to me to afford the greatest amount of security against an attack with similar arms, and being simple in construction and portable in form, it is capable of being adapted to almost every situation where loopholes are required, some few of which I have endeavoured to explain and illustrate in the accompanying memorandum and drawing.

The invention, if I may be permitted to use the term, may at this juncture of the war in Europe, be found worthy of more particular notice, and therefore, subject however to your superior judgment in such matters, I would beg to suggest that the accompanying plans and the models A and B be submitted to the Inspector General of Fortifications, together with such observations as you may consider necessary to make, in reference thereto, for his information and that of the Honourable the Master General and Board of Ordnance.

I have the honor to be, Sir,
Your most obedient humble servant,
T. F. HANLON, Clerk of Works,
Royal Engineer Department.

To Lieutenant Colonel R. Stotherd,
Commanding Royal Engineer, Nova Scotia.

Record of Experiments Carried on by Direction of the Inspector General of Fortifications, with a Metal Revolving Loophole, Invented by Mr. Hanlon, Clerk of Works; and Submitted by Lieutenant Colonel Stotherd, Commanding Royal Engineer, Halifax, Nova Scotia, under date 15th February, 1855.

Royal Engineer Establishment,
Chatham, July, 1855.

A loophole was cast of gun metal, using one of the models sent by Mr. Hanlon to form a mould, it weighed 19 lbs., and cost £1. 5s. 4d. On the 23rd of May, 1855, it was fixed in a musket-proof embrasure-shutter, and was fired from; it was found to afford a very convenient rest for a musket, the muzzle penetrating the loophole 2 or 3 inches only: the loophole traversed easily, and commanded a horizontal range of $75\frac{1}{2}°$ in its front; it also allowed of a depression of $19\frac{1}{2}°$, and an elevation of 14°.

Afterwards the loophole was fired at from the outside: from the small size of the surface of the metal it was very difficult to hit at all; out of 33 shots only 2 went through the opening, one struck the edge of the opening, and bent it inwards about a third of an inch—shewing that three or four such hits would so far close the opening, as to prevent the muzzle of a musket from passing through it. Two shots struck exactly between the box and the traversing portion of the loophole without injuring either in any way, as it still traversed freely.

Finding that the arrises of the gun metal loophole were bent by the blow of a bullet, another was cast of iron, on the same model, having all its arrises rounded, and on the 12th of June practice was carried on against it, similar in every respect to that of the 23rd of May; one shot went through, and another struck the arris of the opening of the loophole without injuring it; a third shot hit the left wing of the box, and partially cracked it; the 4th hit the bottom of the revolving portion, and caused the handle, in the inside, by which it is moved or fixed as a ventilator, to fly off; the 5th hit the right wing of the box, and cracked it through and through at about half its height; and the 6th, hitting very nearly the same spot, displaced a large portion of the lower part of the box and the wings or flanges by which it was fixed, showing that it was not strong enough to resist repeated musket shots. Another iron loophole was therefore cast on a mould having every part of it thickened to three quarters of an inch, and weighing 24 lbs., at a cost of *6s.*: it was fixed, as all the others were, in the old embrasure musket-proof shutter, and was subjected to the same tests from a Miniè musket, and a Victoria carbine. It withstood 10 or 12 hits at the most critical points without being impaired; it fulfilled all the requirements of a loophole, and afforded most effectual cover.

N.B —The three loopholes, above described as fixed in the embrasures, are deposited in the model room at the Royal Engineer Establishment, Chatham.

Royal Engineer Establishment,
Chatham, 3rd July, 1855.

SIR,

With reference to your minute of the 3rd of March last, upon Lieutenant Colonel Stotherd's letter, dated Halifax, Nova Scotia, 15th February, 1855, and its enclosures herewith returned, on the subject of a metal revolving ventilator-loophole, invented by Mr. Hanlon, Clerk of works, I have the honor to report that this loophole presents an opening of only 2½ inches by 1¼ inch, and that it affords a scope of 75½° horizontally, an elevation of 14°, and a depression of 19½°.

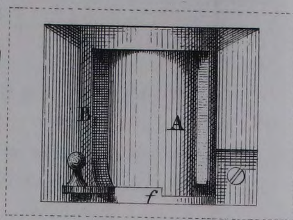
A loophole of gun metal was cast, from the wooden model received with the above correspondence, which weighed 19 lbs., and cost £1. 5s. 4d.; but the metal was found to yield on being struck by a musket ball, and another was cast, from the same model, of iron, but the flanges and box were too thin, and broke after being struck two or three times; a third was then cast of iron, in a fresh mould, thickening only the box and flanges, its total weight being 24 lbs., and its cost only 6s. One will be forwarded to you with the wooden pattern, from which it was cast, marked M. As it was found to resist repeated shots from a Miniè musket, and Victoria carbine, at 40 yards, which struck it in every part without impairing it in any way, I beg to recommend that it be adopted into the service as an article of store.

The wooden models sent by Mr. Hanlon will be deposited in the model room of the Royal Engineer Establishment until they may be required.

I have the honor to be, Sir,
Your most obedient humble servant,
H. SANDHAM,
Colonel Royal Engineers, Director.

To Colonel Matson, Royal Engineers,
Assistant Adjutant General.

FIG. 1.



ELEVATION OF LOOPHOLE WHEN SHUT.

ELEVATION OF PART OF THE INSIDE OF A DOOR FITTED WITH REVOLVING LOOPHOLES, AS IN FIG. 3.

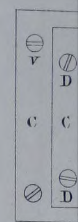


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FIG. 2.

PLAN OF PART OF A DOOR WITH LOOPHOLES FIXED IN I

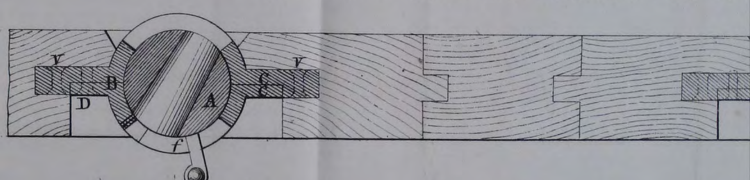
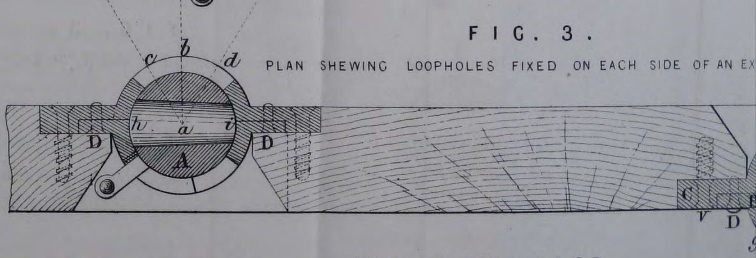


FIG. 3.

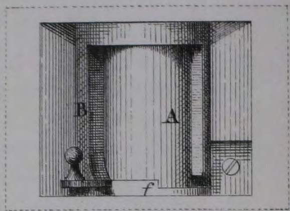
PLAN SHEWING LOOPHOLES FIXED ON EACH SIDE OF AN EX



SCALE FOR FIGS. 1, 2, 3 & 7.
$\frac{1}{4}$th Full Size.

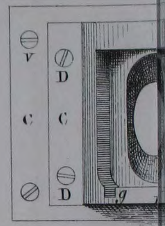
SCALE FOR FIGS. 4, 5, 6, 8, 9 & 10.
$\frac{1}{12}$th Full Size.

FIG. 1.



ELEVATION OF LOOPHOLE
WHEN SHUT.

ELEVATION OF PART OF
THE INSIDE OF A DOOR
FITTED WITH
REVOLVING LOOPHOLES,
AS IN FIG. 3.



ELEVATION OF
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FIG. 2.

PLAN OF PART OF A DOOR WITH LOOPHOLES FIXED IN IT.

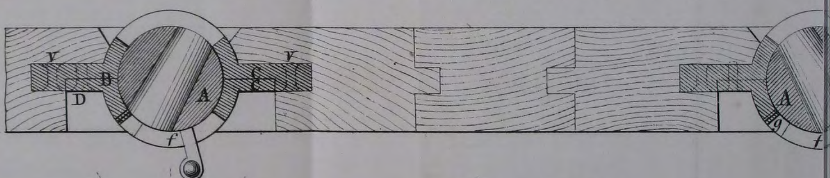
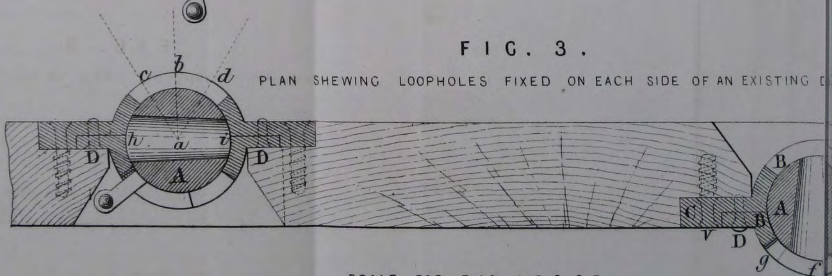


FIG. 3.

PLAN SHEWING LOOPHOLES FIXED ON EACH SIDE OF AN EXISTING D



SCALE FOR FIGS. 1, 2, 3 & 7.
$\frac{1}{4}$TH Full Size.

SCALE FOR FIGS. 4, 5, 6, 8, 9 & 10.
$\frac{1}{12}$TH Full Size.

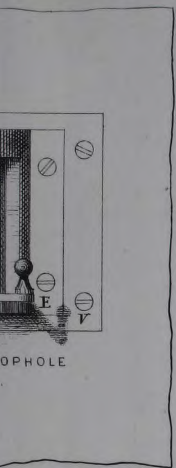
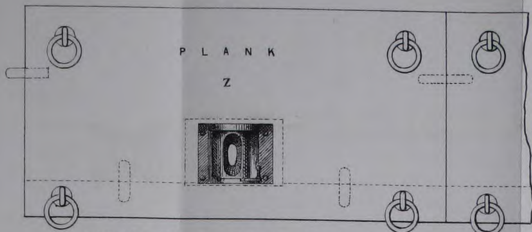


FIG. 4.



ELEVATION OF INSIDE OF SHIELDS.

FIG.

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OF WOODEN S

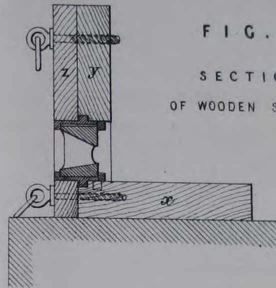
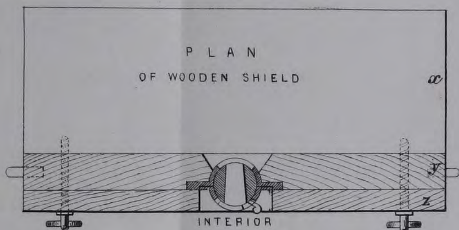


FIG. 6.



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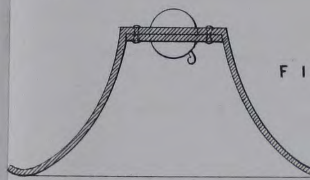
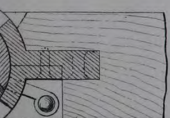


PLAN OF IRON SHIELD.



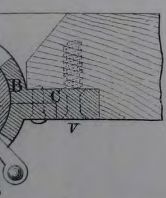
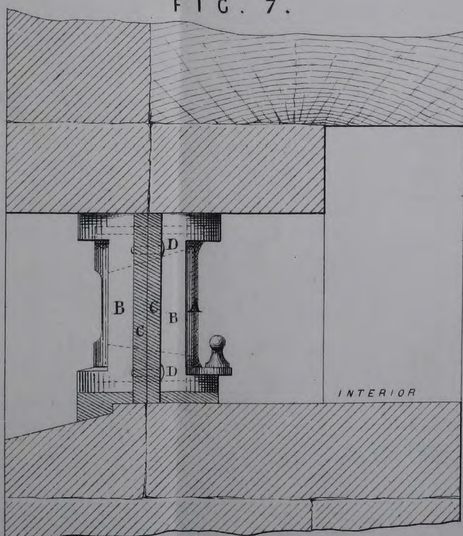


FIG. 7.



SECTION OF LOOPHOLE FIXED IN A WALL.

FIG. 9.
ELEVATION
OF INTERIOR OF IRON SHIELD.

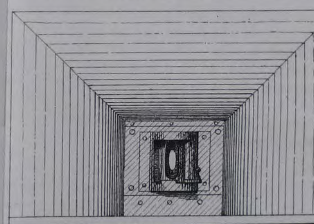
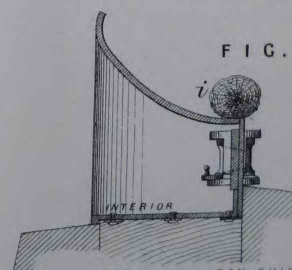


FIG.



SECTION OF IRON SHI

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PAPER XIII.

Reports on the Supply of water at the Camp at Shorncliff, by Lindsey Blyth, Esq.

First Report.

To the Right Honorable Wm. Cowper, M.P., President of the General Board of Health.

General Board of Health, Whitehall, September 15th, 1855.

Sir,

On the receipt of Mr. Peel's letter of the 11th instant, and of a copy of Mr. Denne's letter to Lord Panmure of the 25th of August, I proceeded to the camp at Shorncliff, and put myself in communication with Mr. Denne and Colonel Power, the Commandant of the Camp, who afforded me every facility in procuring the information I required, respecting the supply of water to the camp.

My first object was to obtain a knowledge of the geological formation of the water-bearing strata of the district.

I was referred by Mr. Denne to Mr. Mackeson, a Fellow of the Geological Society, and thoroughly acquainted with the details of the local peculiarities of the district. To this gentleman I am deeply indebted for the kindness with which he placed himself at my disposal, and during two days accompanied me in an examination of the whole district of the lower greensand formation, which at this point extends about six miles along the coast, and from three to five miles inland. It effects a junction with the Gault a little beyond Folkestone, to the east, and with the Wealden at Hythe, towards the west.

The lower greensand formation, which is composed of a variable series of strata, has been very accurately examined at the outcrop in the south-eastern district of Kent, by Dr. Fitton and other eminent geologists. It has been divided into four distinct strata. (See sketch.)

1st. An upper one of white, yellow and ferruginous sands, containing masses of coprolites and pyrites.

2nd. A second one of impermeable clay of a dark colour, contaminated with iron and sulphur: an efflorescence appears on its surface when exposed to the action of the air, which is not only strongly acid to the taste, but leaves a sensation of burning in the throat, and nausea which lasts several hours. This stratum contains no fossils, and it is generally considered by geologists that at the period of its formation some influence existed which was prejudicial to organic life.

3rd. A third consisting of a mixture of sand and limestone, (known as the Kentish rag).

4th. A fourth consisting of clay of fresh water formation, and containing abundance of fossils: it overlies the Weald deposit, and is known in the district as the Atherfield clay.

Second Report.

To the Right Honourable Wm. Cowper, M.P., President of the General Board of Health.

Sir,

Having completed the examination of the samples of water I procured at Shorncliff, I hasten to lay the result before you.

I procured six samples which were taken from the following sources:—

No. 1, from well at Shorncliff opposite canteen No. 1.

No. 2, from well at the camp opposite canteen No. 2.

No. 3, from well at the cavalry barracks, at the back of Colonel Power's house.

No. 4, from a spring at Seabrook, in Horne Street.

No. 5, from a spring on the side of the hill, on which the camp is at present placed, at Hythe.

No. 6, from a spring used by the soldiers at the present camp, at Hythe.

The first three samples from Shorncliff are all derived from the upper series of the lower greensand formation.

The last three are all derived from the lower division, or Kentish rag limestone, of the same formation.

A preliminary qualitative examination showed the following substances to be present.

Lime,
Magnesia,
Silica,
Soda,
Iron,
Carbonic acid,
Chlorine,
Sulphuric acid,
Ammonia,
Organic matter,
Mechanical impurity.

The quantities of each of these constituents were sought for in the usual manner, and the following Table will show the proportion of each, in grains, existing in an imperial gallon of each sample.

	UPPER STRATUM.			LOWER STRATUM.		
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Chloride of Magnesium	trace	trace	..	1·12	trace	trace
Chloride of Calcium	trace	2·45	..	trace	trace	trace
Chloride of Sodium (common salt)	10·45	12·00	9·38	4·26	2·43	2·86
Carbonate of Magnesia	1·46	1·24	1·35	1·78	2·45	1·98
Carbonate of Zinc	2·24	2·45	2·86	16·38	14·70	15·36
Silica	8·05	8·40	2·01	3·62	3·08	3·24
Iron	trace	trace	trace	trace	trace	trace
Sulphates	trace	trace	..	trace	trace	trace
Nitrates	trace	trace	..	..	trace	..
Ammonia	trace	trace	..	..	..	..
Organic matter	3·40	3·46	1·90	trace	trace	0·78
Total soluble matter	25·60	30 00	17·50	27·16	22·66	24·22
Mechanical impurity..	copious deposit.	copious deposit.	moderate deposit.	no deposit.	very slight deposit.	slight deposit.
	Grit Confervæ Infusoria.	Grit Confervæ Infusoria.	Grit Confervæ Infusoria Crustacea	none.	Grit Confervæ	Grit Confervæ

Nos. 1 and 2 were taken from wells recently sunk at Shorncliff, and were those most in use by the men. Their analysis shows them to be highly impregnated with saline matter, silica, and organic matter in a soluble form : when drawn up from the wells, they were turbid, had a bad taste, and No. 2 had a bad smell; on being set aside for a few hours they deposited a copious sediment, and the water remained clear above. It was the bright portion that gave the results of the analysis, the deposit was examined by the microscope, and found to consist principally of the lowest forms of vegetable and animal life, viz., confervæ and protozoa, with portions of decomposing vegetable fibre and grit.

No. 3 was taken from an old well at the cavalry barracks, and though not so highly charged with mineral matter, was also contaminated with organic impurities in a soluble and insoluble state : this water becomes offensive after being kept 24 hours. The deposit was not so abundant from this sample as that from Nos. 1 and 2, but the microscope revealed, besides masses of confervæ, a higher degree of development of the animalculæ existing in it.

In this sample only was any appreciable amount of metallic contamination found, less than a grain of iron being found in the gallon, which probably existed in the form of carbonate in the protoxide.

Whatever may be the source of the contamination of the wells at Shorncliff, whether from the strata through which the water has percolated, or from the drainage of the surface of the soil into the wells, it is evident that there is sufficient contamination to render the water unfit for consumption.

No. 4, which flows from the spring in Horne Street, at the foot of the hill on which the camp was placed at Shorncliff, although highly charged with mineral matter, contains but a trace of organic matter in solution, and left no sediment whatever on standing. The solid constituents partake of the character of the rock from which it issues, and consist principally of lime, which is soluble in carbonic acid. The water contains a large quantity of carbonic acid in a free state, which imparts a freshness to its taste which is very agreeable ; but on exposure to the air, this gas flies off, and the lime which it held in solution will be deposited in an insoluble form. The same effect would be produced by boiling the water, and if it should be thought desirable, the lime might be got rid of to a still larger extent by Dr. Clarke's softening process, and then the water would be rendered comparatively pure : the chloride of sodium or common salt can hardly be considered as deleterious.

Nos. 5 and 6, taken from the hill at Hythe, to which the camp was removed, and issuing from the same subdivision of the lower greensand as No. 4, partakes of the same characteristics; the small amount of organic matter may be accounted for by the fields above the camp being cultivated, as the water which percolates through them would be likely to be contaminated to a certain extent.

From these facts we may draw the following conclusions :—

1st. That the water in the wells at Shorncliff is unwholesome and unfit for consumption.

2nd. That the variable nature of the composition of the geological formation from which it is derived renders it unwise to draw the supply from it, if a purer water can be obtained.

3rd. That the water from the next series in the formation is of a more permanent kind, and is purer and fresher in its character.

4th. That from the peculiar arrangement of the strata in the neighbourhood a supply might readily be obtained from that source. See accompanying sketch.

In conclusion, I would most respectfully suggest that in all arrangements for supplying a large body of persons with water, especial care should be taken to preserve the general supply from contamination from organic impurities, arising from surface drainage.

I have the honor to be, Sir,
Your most obedient servant,
(Signed) LINDSEY BLYTH.

General Board of Health,
September 26th, 1855.

PAPER XIV.

On Batteries for the Defence of Coasts, and the Adaptation of Gun Carriages to them.

By MAJOR GENERAL YULE,

Accompanied by Projects for their Improvement by Major General Yule, Colonel F. R. Thomson, Colonel Sandham, and Captain Fowke, R.E.

The large size of the external opening given to embrasures strikes every one who examines a battery, and the impression made upon a stranger to fortifications is that it seems more adapted to facilitate than to prevent the admission of cannon shot; yet successive military writers have handed down the existing form, as if the rule for it were infallible, not that they have been insensible to its defects, but because they have been accustomed to the idea of considering these so inherent in the construction as to be unavoidable.

Saint-Paul, in his standard work on Fortification, vol. 1, page 137, (edition of 1818), says that the form of embrasures has changed according to the ideas of individual Engineers. Some placed the throat or narrow part in the middle of the opening; others at the outer end, so as to be liable to injury by the fire of its own gun, to avoid which the throat was made at the inner end; but the latter form, which is the existing one, tending to conduct the shot by deflection into the battery, it was sought to prevent this by constructing the embrasures en cremaillière, which Saint-Paul justly ridicules.

The balance of advantages was established in favor of the existing form, and various means have been tried to get rid of its disadvantages.*

One of the first changes adopted for this purpose was to mount guns en barbette on traversing platforms, by which both greater security and wider range were obtained for the guns; but this kind of platform being necessarily high, especially in works in an elevated situation, a great improvement was introduced by Colonel Emmett, R.E., in the substitution of the dwarf traversing platform which is still in use; security for the men and guns is retained, while facility for working the guns is increased.

* Some very ingenious forms of the cheeks of embrasures have been proposed in the Corps Papers, but I am inclined to agree with the opinion expressed in a Note at page 315, article "Loophole," in the 'Aide Memoire,' that a doubt may fairly be expressed as to whether the advantages expected from the more complicated forms proposed are really equivalent to the disadvantages which attend them on service."

The dwarf traversing platform was at first placed behind an embrasure, but recently en barbette, and on raised racers.

In this construction the gun, after recoil, is more speedily run up by the truck lever than by the old method by means of handspikes; but time is lost by the man who lays the gun having to descend from the platform before it can be fired.

While so many new batteries are in the course of being built, the time seems well chosen for further consideration of this feature of defensive works, with a view either to some obvious improvement of its form, so as to meet the objections universally made to it, or to a more distinct understanding of the value which should be attached to it.

Accordingly a circular was sent by the Inspector General of Fortifications to commanding officers of Engineers, dated 11th March, 1854, inviting them, and the officers under them, to prepare projects for the improvement of openings for guns, subject to the following conditions.

"1st. That the gun shall have the usual traversing range laterally, and power of elevation and depression.

2nd. That the masonry shall not be liable to any injury from the explosion of the piece, under any circumstances of being traversed, elevated, or depressed.

3rd. That the front cover shall be sufficiently substantial to resist single shot or shells from the enemy, even at considerable velocities.

4th. That there shall be room within the casemate for working and serving the gun freely, even under the circumstances of extreme lateral traversing; and that the external opening shall be as small as possible, consistent with obtaining the above desiderata in the greatest degree.

The projects should be applied to the garrison carriage and to the dwarf traversing platform. To facilitate the consideration of the question, it may be assumed that there is no difficulty in making the gun traverse on a pivot under its muzzle, instead of being immediately in front of, and close to, the carriage,; and also it may be admitted that considerable blocks of granite or other hard stone, of 50 or 60 cubic feet each, may be obtained for the outer opening."

I confess that I was so biased by the habit of considering embrasures unimprovable, on account of the opinions not only of old, but of modern military writers, that I looked upon the subject as exhausted, and my first conviction, after reading the above conditions, was that they were irreconcileable, the latter part of condition No. 4 appearing to contradict the preceding three, for it is in giving the opening the usual lateral scope that the desired security for the gunners and guns is diminished: it was not apparent how the same openings could be both substantial and affording great range, and the only way to fulfil both conditions seemed to be, for the one, to make the cheeks of the embrasure to open outwardly little, if at all; and for the other condition, viz., range, to multiply the number of guns in a battery so as to command, by direct fire and without traversing, every part of the space opposite to it; thus each ship would be seen as it, in succession, entered within the space.

In proportion to the lessening of the scope of the embrasures, it is obvious that their number must be increased; for instance, if it be made $\frac{1}{2}$ or $\frac{1}{3}$ of what it was before, the number of them should be double or treble.

It was given as a reason against reducing the size of the embrasures, that the explosion of their own guns would injure them, but it is surely better to commence an action with all the security afforded by the small opening, than to give the enemy the advantage of finding them ready made, instead of having to widen them at their own risk and loss of time.

As long as sailing vessels alone existed, the present form of embrasures was not inadequate for its object, as a sure, close, and concentrated fire could not always be brought against a battery; but it is not sufficient to resist the attacks of fleets of large ships when placed in position by means of screw power, under the supposition, at least, that there are fewer guns in the battery than in the ships brought against it.

It is to be observed that batteries against ships need not be constructed to oppose their direct broadside fire ; positions may in preference be chosen, so as to rake them while they move or be " end on," and even 3 or 4 guns only, placed at intervals, and in a variety of positions, may be more effectual than a battery of ten times the size, on which a ship's broadside can be brought to bear.

According to this view, such batteries should be made to fire along a coast as well as directly towards the sea ; and especially on the banks of rivers, to fire up and down rather than across, having epaulments at the river or sea flank, so as to give protection from broadside fire.

A ship taking up a position against a battery of this kind is exposed to be raked ; it is only her stern and bow guns which could bear directly upon the battery, while her broadside fire must necessarily be distant from its object, and therefore at a disadvantage.

It is desirable that masonry should be sparingly used in such works; in general earth alone is best, especially in all external parts ; but when space is limited, masonry is sometimes necessary throughout.

It may also be remarked that as guns in coast batteries are not usually exposed to vertical or enfilading fire, it is not necessary to place them in casemates ; traverses may however be erected close to the parapets of open batteries to protect the gunners from the effect of shells.

There was certainly some foundation for the prevailing popular impression respecting the power of ships' fire, but as it seemed to be greatly exaggerated, the Duke of Wellington considered it so important to remove the erroneous opinions about stone walls and ships, that he took an opportunity, in his place in the House of Lords, to advert to it after the capture of Acre, which he seemed to consider as a fortuitous event, on which no calculation of future success ought to be founded. Even while this is being written the opinion of so high a naval authority as Lord Dundonald has been expressed on the subject, and ought to put the question at rest ; he states in his letter to the Editor of the " Sun," dated September 21st, 1854, that success could not have attended the operations of combustible ships against stone batteries firing red hot shot, however coolly unresisting walls may be leisurely demolished.

It is well known that at Algiers a single gun, from a distance, continued its fire on our ships after the batteries on the sea-walls had been silenced, and the repulse of a British ship of war, by a gun on a Martello tower in Corsica, led to the introduction of that useful description of battery into our coast defences. These cases shew that the strength of a battery does not depend so much on the number of its guns, as on its site with reference to the position of the assailants.

If it be granted to popular partiality for the sake of argument, idle as it is, that stone walls are inferior to ships, the consistent course of the advocates for the latter would be to recommend the erection of batteries of wood to resemble ships' sides.

Our naval forces are increased indefinitely ; ship after ship is laid down without challenge, because the popular feeling is that ships we must have ; whilst the security which can be given only by defensive works on land, being thought less requisite, means for obtaining it are sparingly, if not grudgingly, afforded by the country.

A ship of war costs, in ordinary phraseology, £1,000 a gun, when completely fitted out ; so that the price of four large ships exceeds the sum now proposed to be expended on our most important strongholds, Gibraltar and Malta, (although they are chiefly of value to us as naval stations), to put them on a footing with the power of attack afforded by steam ships.

It is to be borne in mind too, in considering the comparative cost of ships and stone walls, that the latter are of permanent construction.

There is a prominent defect in existing fortifications, built at a time when sailing vessels alone were to be resisted, which the introduction of steam ships makes it necessary to remedy; this defect is the exposure of the escarp walls.

It was not important of old to provide coast defences with those elements of every work of fortification, glacis and counterscarp, in order to give cover to the escarps. Against batteries protected by these, ships, of whatever size and number, could do little more than destroy embrasures and dismount guns, while the garrison would remain quite secure against every attempt at capture by assault. This deficiency in sea batteries has been felt by military Engineers since the introduction of steam vessels, and opportunities have been taken to supply it.

There is also a popular error, in disparagement of fortifications, which deserves notice as requiring to be removed. When Malta, for instance, happens to be without ships, there is (or at least, was, when I was there), an outcry about these places being left unprotected, just as if the object of harbours, with their proper adjuncts of fortifications, were not specially to afford security to ships of war as well as of commerce, and not to derive it from the former. Certainly a fleet could not be more unprofitably and unsuitably employed than in guarding such a harbour as Malta.

Guns are made and accumulated at Woolwich by thousands, and there are always many available for the coast, where their number should be increased, and they might be worked by the nearest inhabitants. The expense of making cover for them would be small: a simple earthen parapet enclosed behind by a wall, by a guard house, which should be loop-holed, and a small magazine, would be sufficient.

The people would probably take a pride in these local armaments, as better suited to the more intelligent of our artizans than ordinary small arm drill as infantry.

Officers of the Royal Artillery should have charge of districts having such batteries in every accessible part of the coast.

I am aware that such a general plan is not according to the common military maxims regarding extended frontier defence, which maxims, however, being written by continental authors (our chief authority, until of late years, in military matters), are not applicable to a coast like ours (especially since the use of steam in ships), but only to continuous lines of rivers or mountains.

It may not be out of place to remark that there would be no cause for constitutional jealousy in an unlimited force of garrison artillery to be placed in batteries along our shores, because they could be available for that object alone, and it is almost certain that such an Artillery establishment would not only be a great means of security, but would become the favourite national service.

Some of the projects sent to the Inspector General of Fortifications, in reply to the circular above-mentioned, will be described below.

P. YULE,
Colonel Royal Engineers.

June, 1855.

No. 1 PROJECT.

DESCRIPTION OF EMBRASURES, AND TRAVERSING CARRIAGES ADAPTED TO THEM, ACCORDING TO THE CONDITIONS PRESCRIBED IN THE CIRCULAR OF THE INSPECTOR GENERAL OF FORTIFICATIONS, DATED 11TH OF MARCH, 1854; PROPOSED BY MAJOR GENERAL YULE.

It being required that the usual traversing range laterally, and the power of elevating and depressing the guns, be preserved, it is proposed—

1. To reverse the ordinary shape of openings for guns in casemates and batteries, and to make them externally as in fig. 1, plate 1, or not larger than to allow the muzzle of the gun to protrude beyond the masonry; and their internal openings large enough to give the usual lateral range.

2. To mount the gun on a garrison carriage, from the front of which projects a wooden bearer *b* (figs. 1 and 2, plate 1), about 7 inches in diameter at the end, which will rest on a ledge or socket in the genouillère when the gun is run up.

3. To make a platform of masonry, and of the usual form, except that where the rear trucks of the garrison carriage rest when the gun is run up, a circular groove, about 1 foot broad and 1 foot deep, will be left in the masonry to receive a revolving or "traversing table" of wood (*t*) covered with a plate of iron (see figs. 1 and 2), the top of which will be in the same plane as the platform, so that it will present no obstacle to the recoil of the gun carriage.

The traversing table will be prolonged under the parapet according to the extent of the horizontal range; on it will be fixed a rack having teeth to correspond with the pinions of a winch, by which the table will be moved and the gun traversed.

Under the front trucks also a shallow groove *h* will be cut in the masonry, so that the carriage, when run up will rest only on the rear trucks, and on the bearer, the end of which latter will serve as a pivot, the weight of the gun retaining the carriage in its position during the operation of traversing by the winch.

The advantages of this construction are.—1st. its fulfilment of the conditions 1, 2 and 4, of the circular of 11th March, 1854, with the exception of its application to the dwarf traversing platform, which however will not be required, as the garrison carriage itself will be capable of rapid traversing, and may supersede the other.

With respect to condition No. 3, requiring that the front cover be sufficiently substantial to resist single shot or shells, it will be necessary to add the masses* A and B (fig. 2) to the parapet, but this would be a return to the old funnel shape.

2. With the proposed construction of carriages, all the rapidity of fire of the ordinary traversing platform would be preserved, without the embarrassment and delay which the latter would cause in action, if injured by shot or otherwise. To replace a traversing platform, and remount on it a garrison carriage and a gun, will take much longer time than merely to bring forward a garrison carriage and mount a gun upon it.

3. It seems to meet the requirements mentioned in the confidential circular from the Master General and Board of Ordnance, dated 28th January, 1853, $\frac{M}{612}$; as well as those stated by Sir John Burgoyne in his paper on Coast Defences, vol. 1, New Series of Professional Papers of the Royal Engineers.

* It may be useful to state here that late experiments prove that 68-pounder shot fired with service charges, at a range of 300 yards, penetrate only 1 inch into solid granite masonry.—ED.

4. The winch, as well as the man to work it, will be quite secure from any direct fire.

5. The time required for the man laying the gun to descend to the ground before it is fired, as is the case with the traversing platform, will not be lost; (and during this interval of time, the accuracy of aim is necessarily affected by the change of place of the object fired at, as for instance a ship.)

6. There will be less risk in case of great recoil.

7. The cheeks of the embrasures will be more substantial, as they will be perpendicular, instead of being made with the slope sometimes given to the existing embrasures to save them from the explosion of the gun.

8. Fewer men will be required to traverse; two men to run the gun up, and one man at the winch will be sufficient.

9. The platform may be as steep as is requisite to facilitate the running up of the gun; that is, as steep as the existing traversing platform.

The feasibility of giving more than the usual steepness to the platform arises from the gun being traversed on a horizontal plane, which can never be done in the common ground platform, as may be explained thus: when the gun on the common ground platform is pointed directly to the front, its position is true, each pair of trucks resting at the same level; but in every other position, where the gun is pointed to the one side or the other, all the four trucks are on different levels (although still on the same plane), consequently the elevation of the gun, especially, is not only theoretically, but practically, erroneous, and no accurate allowance can be made for it.

This defect, which does not appear to have been alluded to before, is unavoidable in the common platform, but does not exist in the proposed traversing garrison carriage, as the traversing table, and the platform in rear of it, radiate from the pivot as a centre, and the gun will not recoil on a slope until it is clear of the traversing table.

10. It is evident that the nearer the front end of the bearer is to the muzzle of the gun the greater is the thickness which can be given to the parapet at the genouillère; and it is only necessary to make the bearer strong in proportion to its length.

The carriages might also be made higher, so as to allow the genouillère to be raised, and thus give more cover to the gunners: additional height being given to the carriage, proportionate stability would have to be given to it by lengthening the axles of the trucks, for the cheeks of the carriage cannot be placed farther apart than at present.

As it occurred to me that an objection might be made to the form of the "bearer" projecting from the carriage, which would necessarily limit the use of such a carriage to one description of platform, another plan is shewn in figs. 2 and 3, in which the bearer (*p*) is separate from the carriage, but is connected with it when the gun is run up, yet not so as to impede the recoil. The bearer will remain on the genouillère attached to it by a pin at the outer end, and supported by small trucks underneath; and a socket must be made in the front of the ordinary garrison carriage to receive it. This answers very well in the model.

In fig. 3, the external opening of the embrasure is represented as closed by a wooden rifle-proof shutter (*s*), intended to be fixed on hinges, and to be moved by a chain passing over the parapet to the inside of the battery*; and it may be attached to the masonry as in fig. 3, or be fixed on detached posts, which seems preferable, as being more easily replaced if injured.

P. YULE,
Colonel Royal Engineers.

* In the "Aide Memoire to the Military Sciences," is a plate (see article on Mantlets) which represents various kinds of shutters in use; and hanging screens, formed of rope, have also been found useful as a protection against the fire of riflemen.—Ed.

No. 2 PROJECT.

LETTER FROM COLONEL F. R. THOMSON, COMMANDING ROYAL ENGINEER AT MALTA, TO THE INSPECTOR GENERAL OF FORTIFICATIONS, TRANSMITTING DRAWINGS OF A PROPOSED CASEMATED EMBRASURE FOR SEA BATTERIES.

Royal Engineer Office,
Malta, 27*th May,* 1854.

SIR,

1. In reference to the circular of the 11th March last, I have the honor to transmit drawings,* numbered 1 to 4, of a casemated embrasure to be used in sea batteries for guns on dwarf traversing platforms, and which I propose should be constructed partly of cast iron and partly of stone, as is, I trust, sufficiently shown, and which, I conceive, if feasible, embraces the whole of the desiderata pointed out in the circular.

2. For guns mounted on garrison carriages, the opening, as well as the quantity of iron, could be diminished.

3. Being ignorant of the effect of shot with considerable velocity impinging on cast iron, except so far as appears from the unsatisfactory experiments mentioned in General Paixhan's notes, I have felt some diffidence in forwarding this project. I would submit that it is most desirable that experiments should be made to some extent, either by constructing one or two embrasures, as here proposed, or in some other way, to be fired through and at, in order to obtain data for guidance in bringing forward schemes involving the use of iron in works of defence, and thus obviate the necessity for assuming dimensions, as I have now done, which probably may require great modification, if they are not found erroneous, when actually tested.

I have the honor to be, Sir,
Your most obedient humble Servant,
FRANCIS RINGLER THOMSON,
Lieutenant Colonel, Commanding Royal Engineer.

No. 3 PROJECT.

DESCRIPTION OF THE EMBRASURE PROPOSED BY COLONEL SANDHAM, R.E.

The accompanying plan, fig. 4, plate 2, shew a platform and embrasure which appear to fulfil the conditions enumerated in the circular of the Inspector General of Fortifications, dated March 11th, 1854.

The platform is provided with iron trucks having the tires hollowed, as proposed by the late Colonel Colquhoun, R.A., so as to travel on ribbed, or raised racers, (as

* Figs. 1, 2, and 3, plate 2, represent the plan, elevation, and section of the embrasure proposed by Colonel Thomson, taken from these drawings.—ED.

shewn in fig 4, plate 3), which prevent the necessity for any pivot, as experiments have proved that 68 pounders can be fired from a platform so constructed without causing any injury to it.

The centre from which the arcs for the racers are traced is under the muzzle of the gun, and 1 foot from the outer face of the wall ; the width of the embrasure at this point, so as to allow of a total range of 60°, is only 2 feet 6 in., which might even be diminished if the swell at the muzzle of the gun were omitted, thus leaving more room for its recoil.

The space required for each platform to afford room for firing with the greatest lateral range is about 24 feet.

Note.—It may here be remarked, that if a shot strikes the cheek of an embrasure having a splay outwardly and built of granite, it will deflect inwards if it strikes at any angle below $27\frac{1}{2}°$, and will break into small pieces so as to cover a circular space 4 feet in diameter at a point 10 feet from the point of impact, which shews in a striking manner the evil arising from this construction, necessarily resulting from placing the pivot, required in using ordinary racers, inside the parapet.

No. 4 PROJECT.

Description of a New Form of Reversed Embrasure,

Traversing Platform, and Gun-Carriage, for Coast and other Defences,

Proposed by CAPTAIN FOWKE, Royal Engineers.

So much has been already said and written on the subject of embrasures, and more lately of traversing platforms, the existing forms are so well known, and their respective merits and demerits have been so often and so ably discussed, that any essay on them, or description of their construction, would be quite superfluous in the present paper, in which it will suffice to explain, in as few words as possible, the form and construction of the system now proposed, noticing the principal points of departure from that now in use, and setting forth briefly the advantages which it is hoped to gain by the change.

The project contains—

1st. A reversed casemated embrasure.
2nd. A dwarf traversing platform.
3rd. A gun carriage of a peculiar form.
4th. A new form of terreplein.

1st. *The Embrasure.*—Its construction will be best understood by a reference to the diagram of construction, fig. 1, plate 3, where the line *a a′* represents in plan the exterior, and *b b′* the interior face of a masonry parapet; *x x* is the centre line of the embrasure, in which the point *p*, two feet from the front, is taken as the pivot of the traversing platform. The lines *c d*, *c′ d′*, show the position of the axis of the gun when at the extreme points to which it can be traversed, *e e*, *e′ e′* are lines drawn tangent to the muzzle mouldings and base ring when in this position, and *g h*, *g′ h′*, parallel to them at a distance of 2 inches, give the cheeks of the embrasure. The neck is formed by lines *h k*, *h' k'*, drawn parallel to the axes *c' d'* and *c d* of the gun, from points *h h'*, in line with the pivot, and finally lines *k m*, *k' m'*, from the outside edge of the gun's face, and at 30° to its line of fire, give the positions of the sides of the mouth or exterior opening. Part of the cheek is cut away to receive the trunnions, carriage, and platform, as shewn in the interior elevation and in figs. 3 and 5, and the plan of the embrasure is completed. Its vertical section is determined by the required elevation and depression (in the present instance taken at 12° and 5° respectively), and by the form of the front of the platform which necessitates the removal of a small part of the sole. The formation of the mouth is already described in the construction of the plan.

The advantages are—

1. That the opening *h h'* is the smallest that can be left without removing the muzzle moulding of the gun.

2. The nose or angle of masonry at *h* is the most obtuse possible, with a lateral range of 60°, and is consequently least liable to splinter.

3. The short neck *h k*, *h' k'*, is the only part of the embrasure that will draw in an enemy's shot.

4. The sides *k m*, *k' m'*, of the mouth, being at an angle of 30°, are safe (as proved by experiment) from the effects of the explosion of the gun, and at the same time free from the evil of drawing a shot inwards; as from their being at right angles to the opposite sides of the neck, a shot rebounding from *m k*, or even grazing it, cannot possibly strike *k' h'* at such an angle as to be deflected inwards.

5. The embrasure, being arched over, gives additional cover, and by raising the wall above it sufficiently to form a parapet and banquette, a continuous line of musketry fire may be obtained at a higher level, thus affording many of the advantages of a casemated work without its accompanying drawbacks of expensive construction and difficulty of ventilation.

2nd. *The Traversing Platform* consists merely of two baulks 15″ × 12″, with a wooden transom in rear, and a small iron one in front, and connected by five bolts and nuts, viz., two in rear and three in front; the trucks are fastened to the baulks without the intervention of legs, as at present, those in front being fixed on a single iron plate which runs across the two baulks.

Its advantages are—

1. Extreme simplicity and economy in the number of its parts.

2. The facility with which the baulks and trucks can be replaced on the spot.

3. That by introducing the front part under the cover of the embrasure, this, the most difficult part to repair, is placed in a position in which it is almost positively safe from either direct, enfilade, or vertical fire.

4. That by the same means the width of the terreplein, and space necessary for working the gun, are reduced, and the whole apparatus brought closer to the parapet, and consequently better under its cover.

3rd. *The Gun Carriage.*—Its peculiarity consists in having the cheek so reduced in height as to bring the trunnion of the gun to within 8 inches of the upper surface or slide of the traversing platform, the stool-bed, quoin, &c., being suspended between the baulks of the platform by strong wrought iron straps from the cheeks of the carriage; the usual small trucks are introduced in front, for facility of running the gun up with roller handspikes.

The construction will be best understood by reference to the "details of carriage" in the plate.

The advantages proposed to be gained are—

1. The centre of gravity is lowered, and consequently greater stability is given to the gun.

2. In the recoil the axis or line of motion approaches so nearly to the plane of support that the force and resistance are nearly in the same plane, thus avoiding the cross or diagonal strain to which the present carriage is subject, and relieving the platform in some measure from the downward blow of the concussion.

3. For the same reason it diminishes the tendency of the gun to dismount itself, or fall over backwards, on being fired with a charge of greater power than usual.

4. The gun being at the same height from the ground as if on a common garrison carriage, obviates the necessity of the men exposing themselves by mounting on the traversing platform to load, at the same time giving increased cover to the gun and carriage with the same height of parapet, as may be seen in figs. 6 and 4, where are shown the probable effects of similar shot on the gun, carriage, platform, and gunners, in the present and proposed systems.

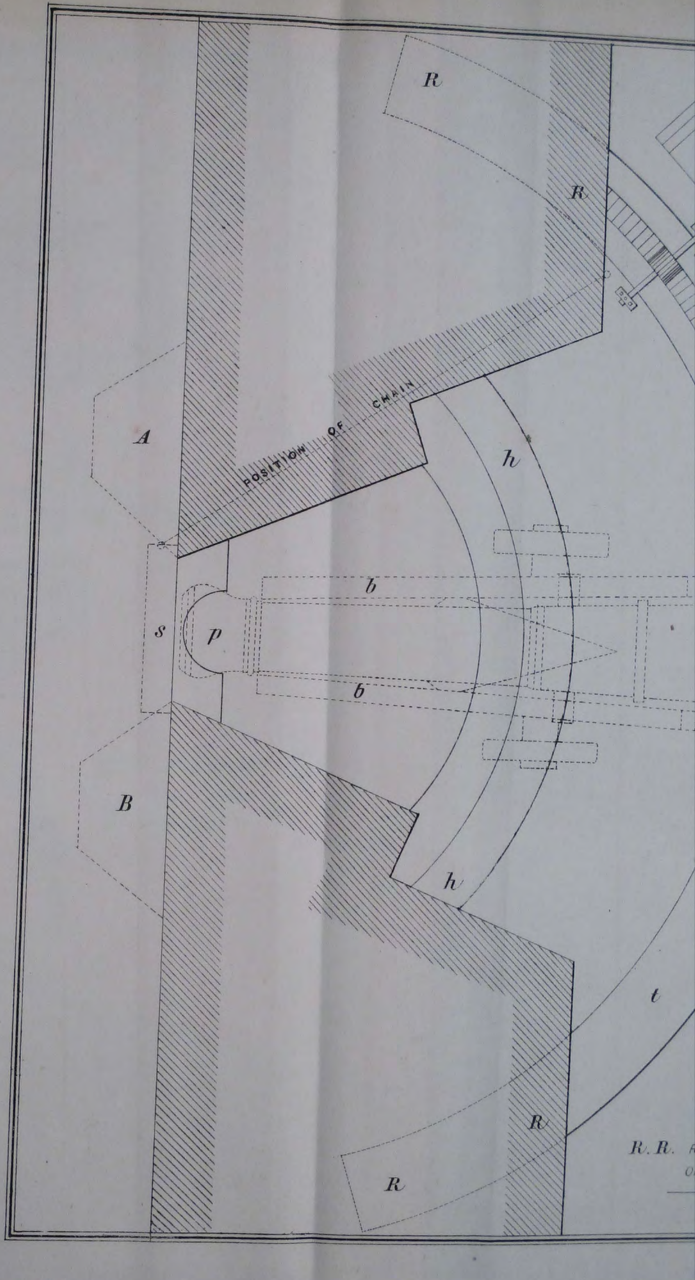
4th. *The terreplein* is sloped upwards towards the rear, parallel to the slide of the platform, for the purpose of keeping the gun always at the same height from the ground, for convenience in loading.

Figs. 2 and 3 shew the system as proposed, with a pivot 1 ft 6 in. from the muzzle of the gun, and connected with the platform by a wrought iron bridle. In figs. 4 and 5 is given a modification of the system with the pivot removed, in which the platform is made to traverse over the necessary segments by means of the grooved truck and ribbed racer or rail, which have been found to answer so well in recent experiments.

In fig. 2 the parapet is shewn with curved exterior and superior slopes, a form that would probably be advantageous in coast batteries which can be approached by shipping, as being less liable to splinter, and having a tendency to deflect upwards those shot fired at point blank range.

FRANCIS FOWKE,
Captain Royal Engineers.

31st January, 1856.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PAPER XV.

Report on Experiments in Making Gabions with Hoop-Iron,

By LIEUTENANT W. A. FRANKLAND, R.E.

From the Records of the Royal Engineer Establishment at Chatham.

Cylindrical Hoop-Iron Gabions.

First Experiment.—Thirteen wooden battens were first driven into the ground about 4 inches apart, and of the same dimensions as in making common gabions; (twelve stakes would not have answered, as the 2nd round of iron would just have covered the first; thereby no support would be given to the battens, and the whole thing would fall to pieces). Hoop iron, 1 inch thick, was then interlaced round them, as in making gabions of brushwood, but using one piece instead of three: this was continued till the web was of the required height; thirty-two rounds were then taken, but the number ought to have been 33, as that would have made it 2 feet 9 inches high; 9 pieces were required, averaging from 25 to 26 feet long; this included sewing on each side; the weight was 42 lbs. The work was commenced by 3 men, but another was found necessary to prevent the stakes from being pressed inwards. They then worked as follows; one man inside the gabion to hold the staves; two to interlace the iron, and one to support the end of it. It was 1½ hours in construction, but if the men were practised it could be done in less than an hour.

Second Experiment.—Another was made in the same way with 1½ inch hoop iron in 40 minutes. It took 7 pieces, each about 27 feet in length; and about 22 rounds; its weight was 53 lbs. In both cases the beginning of the first piece and the end of the last were made fast to the stake by clamping, and it would make the gabion more stable if all the ends were fastened in the same way.

Third Experiment.—The two gabions were then taken to the Butt, and fired at from a Sapper's Victoria carbine at 30 yards; at the first shot the bullet went through the web, and the sewing on the near side of one of them, and through the web on the other side: at the second shot the bullet went through the web on the near side, and the web and sewing on the other, tearing the iron into shreds. Only one shot was fired at each. From this it is evident that they will stand fire as well as the brushwood gabions, without flying to pieces. Their advantages over the common gabions are many—

1st. They are more portable, as they can be taken to pieces and packed.

2nd. They take less time to construct.

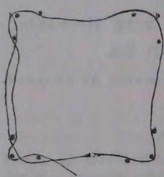
3rd. They are more easily constructed.

4th. They can be constructed where brushwood cannot be procured, and they are not much heavier than gabions of brushwood. They have been successfully made and used at the siege of Sebastopol, the iron being procured from the trusses of compressed hay.

(Signed) W. A. FRANKLAND,
Lieutenant Royal Engineers.

Square Hoop Iron Gabions.

Fourth Experiment.—The dimensions of the first gabion were 1 foot 9 inches square and 2 feet 9 inches high; 12 pickets or battens were then driven in, in the manner shewn in the sketch, so that those at the corners were supported by the iron interlaced between the other two, close to them, the turns of iron which came inside them being bent outwards to meet and support them: this was continued till the web was of the required height. It took 12 lbs. of 1½ inch iron, including sewing; 4 men worked as in making the cylindrical gabions, 1 inside the gabion, 2 interlacing, and 1 holding the end of the piece of iron. The total weight was 48 lbs., and it took 2¾ hours to construct.



Fifth Experiment. — The second gabion was 2 feet square and 2 feet 9 inches high, and was constructed in the same manner, with the exception that there were 16 battens, an additional one being placed in the centre of each side. This gave it greater solidity and neatness of appearance: the same number of men were required, and it took 1¾ hours to construct. The party was a different one from that which constructed the other gabions. The total weight was 59 lbs. The ends of the iron were in both cases fastened as in the round iron gabions.

No further experiments were made with them; they are more difficult to construct than the round ones, and are heavier.

(Signed) W. A. FRANKLAND,
Lieutenant Royal Engineers.

Royal Engineer Establishment,
6th July, 1855.

Memoranda relative to Gabions.

Description.	Dimensions.		Weight.	Cost.
	diameter.	height.	lbs.	s. d.
Cylindrical gabion made of brush wood, in green state	2 ft. 0 in.	2 ft. 9 in	60	4 11½
Ditto in dry state	2 ft. 0 in.	2 ft. 9 in.	40	6 2
Cylindrical gabion of 1 in. hoop iron	2 ft. 0 in.	2 ft. 9 in.	43	7 9
Ditto 1¼ in. ditto	2 ft. 0 in.	2 ft. 9 in.	53	9 0
Square ditto 1¼ in. ditto	2 ft. 0 in. × 2 ft. 0 in.	2 ft. 9 in.	59	10 1½
Ditto 1¼ in. ditto	1 ft. 0 in. × 1 ft. 9 in.	2 ft. 9 in.	48	9 6

(Signed) J. B. BROCK,
Clerk of Works.

PAPER XVI.

REMARKS ON IRON GABIONS.

BY CAPTAIN H. TYLER, ROYAL ENGINEERS.

Gabions appear to have been employed in the year 1629, in the attack on Bois-le-duc, by Prince Edward Henry,[1] as well as in previous sieges; and they have continued to form a most important item of siege equipment ever since.

The first gabions were about the size of the present French "gabion farci" or English sap roller, viz., 5 or 6 feet high, and proportionally broad, but at the siege of Ath, in 1697,[2] they did not exceed 3½ French feet in height. Vauban[3] recommended, for ordinary use, gabions 2½ French feet high by 2½ in diameter, made on pickets 3 feet long; and Cormontaingne[4] preferred smaller gabions, 20 inches in diameter, and 2½ French feet in height, with the pickets projecting 3 inches at top and bottom.

Bousmard[5] prescribes three sizes, to form part of the stores of fortresses, viz., 6 feet high by 3 feet in diameter, for epaulements, temporary traverses, and screens; 4 feet by 3 feet, for traverses on the ramparts and parados; and 3 feet by 2 feet, for masking embrasures, and for repairs.

In the Peninsula[6], gabions were used 3 feet in height by 2 feet 3 inches in diameter; but these were found "unmanageable[7]" for the sap, on account of their great weight, and after repeated trials it was found that the best size was 3 feet high by 18 or 20 inches interior diameter between the stakes.

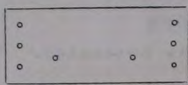
Sir Charles Pasley[8] prefers 2 feet 9 inches in height by 2 feet in diameter; and, in his article on gabions in the "Aide Memoire," Sir John Burgoyne states the smallest admissible for saps at 2 feet 9 inches high by 20 inches in diameter. It appears that at the recent siege of Sebastopol a height of 3 feet was preferred for the batteries.

Gabions have always been constructed of rods of willow, and various pliant woods, twined round fir, or other stakes, in the form of a cylindrical basket; and casks and barrels were found most useful as substitutes for them before Sebastopol, as well as on former occasions. Cormontaingne[9] recommended the use of casks in 1803, and Sir John Jones particularly mentions them in his account of the attack on the castle of Scylla,[10] in 1806.

1 P. 130, Vol. III, New Series, Professional Papers.
2 Plates in "Memoires de M. Goulon."
3 Œuvres de Cormontaingne, Note p. 72, Tom. 1.
4 Ibid, p. 81.
5 Essai General de Fortification, p. 91, Vol. III.
6 Page 90, Vol. I, 3rd edition, Jones's Sieges.
7 Ibid, Vol. II, p. 194.
8 Page 17, Part I, "Practical Operations of a Siege."
9 Page 70, Vol. II, Œuvres de Cormontaingne.
10 Page 231, Vol. II, 3rd Edition, Jones's Sieges.

During the recent operations before Sebastopol, when the want of gabions was sensibly felt, a new mode of supplying them was devised by Lieutenant Elphinstone, R. E., and adopted by Colonel Chapman, R.E. with great success. The wrought iron bands, taken from the hay and from various packages, were used in place of wooden rods, and were " randed " round upright pickets.

The author of this paper begs now to propose to his brother officers the adoption, in certain cases, of a gabion composed of a simple sheet of iron, No. 20 guage, bored with 8 holes: six of these are required for tying the ends together with annealed wire, when the sheet is rolled up in the form of a cylinder, and the other two for the admission of a picket, that the gabion may be carried in the usual manner for commencing a flying sap.



Gabions thus constructed lie flat, in a convenient form for stowage, and may be rolled up and tied into shape with great ease and rapidity when required for use.

Two sheets of this description, " galvanized," were forwarded by the Author to the Royal Engineer Establishment, at Chatham, for experiment, in August, 1853, and many more have since followed, some plain, some galvanized, and others served over, when hot, with boiled oil; and their relative powers of durability in a parapet are now under trial. After having been used in a parallel, some of them were lately placed in a trench cavalier, and blown up by mines; when it was found that very few had been destroyed, and that others, which had been bent, were easily restored to their original shape.

A considerable number were also prepared for service in the Crimea, but owing to delays in shipment, and other circumstances, they did not arrive until some days after the termination of the siege of Sebastopol, and the opportunity of trying them there was thus unfortunately lost.

It is not, of course, to be supposed, that sheet iron would supersede the ordinary basket work for gabions, in cases where materials for the latter are close at hand, and in abundance; but, under other circumstances, and for many purposes, it is believed that they might be used with great advantage, particularly when water transport is available to the scene of operations.

Such circumstances and purposes will now be briefly considered, and reference will be made to a few of the cases in which the old gabions have either been found inefficient, or have been difficult to procure.

At the second siege of St. Sebastian, in 1813, we learn, that[1] " the trenches on the isthmus were improved by the addition of good musketry parapets and banquettes, as fast as fascines and gabions could be procured; but the supply was in no degree commensurate with the demand for them, in consequence of operations having been commenced before any depôt had been formed." Here it may be remarked, that it might, on many occasions, be of great importance to have a reserve supply of sheet iron with a besieging army, in order to save the time that would otherwise be required for collecting materials, and constructing gabions, before the commencement of operations. Delay may often, on account of the proximity of a relieving army, or for other reasons, such as scarcity of provisions, or unhealthiness of situation, be fatal to success.

At the siege of Badajos, in 1812, Sir John Jones[2] mentions that " the 10,000 sand bags which remained unexpended, and 200 gabions and 250 fascines made in the

1 Page 66, Vol. II, 3rd Edition, Jones's Sieges.
2 Note, page 210, Vol. I, Jones's Sieges.

park, were most urgently required at several points during the progress of the attack, but were withheld, and kept in reserve, as the sole means of establishing any close lodgement which might become essential to success." There also a reserve supply of metal gabions would have been of great value.

At the siege of Burgos, in 1812, it is stated that[1] "there being *no gabions to spare* for this service, the men were *set to work uncovered*, but the fire of the place was immediately concentrated on the spot, and in a few minutes, several men having been killed or wounded, the attempt was relinquished." In this case, there was a *useless* sacrifice of men for want of a proper supply of materials, a result which must always be as expensive, in its true sense, as it is deplorable.

The weight of the basket-work gabion varies considerably with the materials which can be procured, and even with the season of the year. The average weight of those[2] in use at Chatham has been computed at 36 lbs, when 2 feet in diameter, and 2 feet 9 inches high. In the Peninsula, they were reduced in size, for sapping, on account of their weight, as the following extract will shew. "After repeated trials[3] it was found that the best size for gabions for the sap is 3 feet in height, by 18 or 20 inches interior diameter between the stakes. The gabions, which were all of green materials, were at first made 3 feet in height by 2 feet 3 inches in diameter; those of oak weighed 20 lbs., and those of willow 80 lbs. The former were found *perfectly unmanageable*; even at 2 feet diameter, those of oak averaged 85 lbs., and those of willow 70 lbs., and were found still too heavy." Such a result would, of course, depend upon the nature of the materials at hand; but it may here be stated that gabions of sheet iron, 3 feet in height, weigh only 26 lbs. The sheet being 6 feet long, their interior diameter would be a little less than 2 feet, but they might, for many purposes, be left open 3 inches, towards the parapet, and they would then attain the largest dimensions specified above. Some hoop-iron gabions, of a similar description to those previously referred to as having been used in the Crimea, were constructed at Chatham not long since, and when made with 1 inch hoop iron, 2 feet 9 inches high, and 2 feet in diameter, were found to weigh 42 lbs; when made with 1½ inch hoop iron, and of the same size, 53 lbs. (See page 91.)

Facility of transport is often of great importance in siege materials. At the siege of Mooltan,[4] 15,000 gabions were prepared at a distance of twenty miles from the place, and about 1,100 journeys of a camel over that distance were required to take them to the front. At the siege of Badajos[5] in 1812, great disadvantages arose from want of gabions, as well, indeed, as for want of guns, mortars, and sappers. Of the 1,200 gabions that were used, 500 were brought up by 1,200 Portuguese militia, and the remainder in the carts or on the mules; as these could be spared from their other duties. It is not of course to be expected, when an army is so miserably supplied with materials as was the British Army during this latter siege, that iron gabions should be provided; but this siege was itself a striking instance of loss of life arising from the deficiency of such materials, and an exemplification of the following most true observation.

[6] "Indeed there is nothing more certain than that the reduction of a fortress must be paid for in materials or men; and that to save the one, the other must be freely sacrificed."

1 Page 295, Vol. I, Jones's Sieges.
2 Page 24, Part I, "Practical Operations of a Siege."
3 Page 194, Vol. II, Jones's Sieges, 3rd Edition.
4 Page 445, 3rd Number of Corps Papers.
5 Pages 155, 137, &c., Vol. I, Jones's Sieges.
6 Page 318, Vol. II, Jones's Sieges. 3rd Edition.

Gabions are among the stores that are most necessary for saving the lives of the men during a siege, as well as in many other military operations, and a few hundred pounds, laid out in supplying an army with a store of such materials, are as nothing in comparison with the valuable lives that they may save, and the delays they may prevent in commencing siege operations. It would therefore seem to be a matter well worthy of consideration, whether it would not be desirable to make a supply of iron gabions, in many cases, a part of the Engineer equipment of an army, not to supersede the employment of basket-work gabions, but as a reserve for emergencies, for cases where the latter cannot be easily obtained, or where there is not sufficient time for their preparation.

As has been already stated, the iron gabions are more easily carried than the others, both on account of their lightness, and of the facility they afford for being stowed away in a small compass, in thin flat sheets.

Another advantage which iron gabions possess, is that of incombustibility. At Badajos[1] "the cavalry of the garrison in a sortie absolutely rode through the Engineer park, and had the opportunity of burning the whole supply of fascines, gabions, &c."

At the attack on the Moro Castle, in Cuba,[2] the besiegers' parapets, which were formed of dry fascines and gabions, were almost entirely consumed by fire.

Sheet iron cylinders would probably be extremely useful for the lining of embrasures, great difficulty having been experienced hitherto in finding, even for permanent works, a material which would, at the same time, best resist the repeated explosions of the gun, best withstand the enemy's projectiles, and offer the greatest facilities for the repair of a damaged parapet, at a reasonable cost.

Sir John Jones says, in reference to the sieges in Spain, "After some hours of heavy firing, which is now practised from heavy guns of iron, the embrasures become utterly shapeless beyond the muzzle of the piece, and all that can be hoped is to preserve two or three feet of tolerable cover next the battery. During these sieges, the embrasures of the several breaching batteries were fresh lined every night; and though every expedient was adopted to give them strength, still they were invariably found on the ensuing evening to have returned to a shapeless hole."

It seems probable that sheet iron gabions, well bedded below the sole of the embrasure, and well secured to the interior of the parapets, may be found to have advantages in withstanding the effect of the explosion, not possessed by any other species of revetment, on account of their smoothness, their incombustibility, and the tenacity of their material; but this has yet to be tried.

For works which it is absolutely necessary to throw up in a hurry, such as intrenched positions during the advance of a hostile army, or on the coast at the approach of a hostile fleet, these gabions would be valuable for lining the interior slopes of the parapets, and even, in some cases, the escarps and counterscarps, on account of the facility with which they could be conveyed to any required spot, and the rapidity with which the works might be executed. Having regard to the employment of a material affording the most ready means of repairing parapets damaged by shot and shell, it is possible, also, that sheet iron cylinders might be advantageously employed in revetting the merlons of works of a permanent character.

The comparative cost of a revetment of sheet iron gabions, and one of brick, for the interior lining of a parapet, may be stated as follows :—

1 Page 184, Jones's Sieges, 3rd Edition.
2 Page 344, Vol. II, Ibid.

A rod of brickwork would revet and form the footings for an interior slope 50 feet long and 5 feet high, and the cost of this would be £13 15 0

Whilst 50 gabions, occupying, in a double row, the same length of interior slope, would cost, if each gabion were 2 feet 6 inches high,—

For plain gabions without preservative preparation £8 6 7

For gabions prepared, when hot, with boiled oil. 11 13 4

In making this comparison, however, it must be remembered that the foundations of brickwork will give increased trouble, and cause additional expense, when the interior slope is on a rampart of made earth; and that in parapets of greater height, the base of the brickwork would have to be increased, and would, up to the point at which gabions continue to be available for revetment, become, therefore, comparatively more and more expensive. For facility of transport, or in the case of works required to be hurriedly executed, the advantages would be altogether on the side of the metal gabions.

The relative cost and weight of gabions of different descriptions, and all, with the exceptions stated, of the same size (2 feet 9 inches high by 2 feet in diameter), as those in common use at the Royal Engineer Establishment at Chatham, is shewn in the following Table[1] :—

Description.	Weight.	Cost.
	lbs.	s. d.
Round gabion of 1 inch hoop iron	43	7 9
Ditto 1½ inch hoop iron	53	9 0
Round gabion, made of brushwood, in green state	60	4 11½
Ditto ditto in dry state	40	6 2
Sheet iron gabion, served when hot with boiled oil	22½	5 1
Sheet iron gabion, served with boiled oil, 2 ft. 6 in. high	18½	4 8
Plain sheet iron gabion, . . 2 ft. 6 in. high	18½	3 4

The last mentioned would probably be useful for some works, only intended to serve a temporary purpose, and in cases where the gabions would not be required afterwards; and is by far the cheapest material that could be used.

In the case of sheet iron gabions employed for works of a more permanent character, or in the case of gabions lodged in store, as in a fortress, (where they could be stowed away in a small compass, and with security from the risk of fire,) it might be considered desirable to use galvanized iron, which would be more expensive, viz.,—

		s. d.
For a height of	2 ft. 6 in.	5 11
Ditto	2 ft. 8 in.	6 4
Ditto	3 ft. 0 in.	7 1

1 Extracted from a statement supplied by Mr. Brock, Clerk of works, at Chatham, as far as hoop iron and brushwood gabions are concerned.

Round gabions have been objected to for the sap, because the smaller descriptions of projectiles make their way through, between them, and square gabions have been stated to be preferable. To answer this requirement, the sheet iron gabions might be bent into a square form, with almost the same facility as into a round one; but it would evidently not be desirable to use them in a square form, in the general way, for two reasons.

1. They could not be restored to their original shape without injury, after having been bent at the corners.

2. Their durability would be endangered by the exposure of the angles, particularly if any preservative process had been employed, because the coating, of whatever nature, would be more or less cracked in the operation of bending.

For fastening sheet iron gabions, annealed iron wire is recommended; and this would probably be sufficient in most cases; though, if greater stiffness were required, and if the gabions were not wanted to be removed, or restored to the form of a sheet, they might with most equal facility be secured with " snap " rivets.

It may be convenient to sum up, here, the advantages expected from the sheet-iron gabion.

1. Simplicity, it being merely a sheet of iron.

2. Strength and durability, as compared with the brushwood gabion.

3. Lightness, as compared with the brushwood gabion, inasmuch as it weighs 22, instead of 40 or 50 pounds.

4. Incombustibility, and greater resistance to destruction from constant explosions in embrasures.

4. Facility of form for transport. (Flat thin sheets instead of brushwood cylinders.)

In conclusion, it must be added that a great part of the recommendations, for the adaptation and employment of sheet iron gabions, herein set forth, have arisen in the course of a correspondence between the author and Sir John Burgoyne; and that whilst the defects of the present paper are entirely due to the former, to the experience of the latter must be attributed any practical benefit that may be derived from it.

H. W. TYLER,
Captain, Royal Engineers.

Railway Department,
Board of Trade, Whitehall,
February 29th, 1856.

PAPER XVII.

Notes on the Operations on the Coasts of Circassia and Georgia in 1854.

By LIEUTENANT G. R. LEMPRIÈRE, Royal Engineers.

Having, whilst at Varna, received orders on the night of the 6th of July, 1854, to proceed at day light on the following morning to the Coasts of Circassia and Georgia, for the purpose of placing in a state of defence some of the towns in those countries, which had lately been wrested from the Russians, and were now menaced by them, I called, agreeably to instructions, on Captain Dacres, who was the senior naval officer then at Varna, and was acquainted with that coast. By him, I was given to understand that Redout Kaleh was threatened by the enemy, and that an attack upon it was daily expected. A Turkish garrison had been thrown into it, after the town had been evacuated by the enemy on its bombardment by part of the allied fleet, consisting of the Agamemnon, Charlemagne, Mogador, and Sampson, on the 19th May, 1854. My attention was to be particularly directed to this point, as being a most important position to hold, on account of its being the nearest port to Tiflis, this route affording the enemy great facilities for supplying that portion of their army acting against the Turks and the Circassian tribes.

With the assistance afforded me by Captain Dacres, I obtained a passage to Churuk-Su, and thence to Redout Kaleh, in the French steam-frigate " Vauban," about to proceed to the former place, and to be followed by three or four Turkish steamers with reinforcements for the army of Selim Pacha, which had, unfortunately, a short time previous to this been defeated at Tcholok, near Ossurgheti, obliging them to fall back upon the latter place. Colonel Gordon, of the Royal Engineers, proceeded by the same vessel, for the purpose of making a reconnaissance of the whole coast.

At 12 A.M. on the same day (the 7th) we weighed anchor, with 1,200 Turks on board, and about noon of the 9th were off Sinope. The Turkish portion of this town was almost entirely destroyed, and the remains of thirteen vessels which suffered at the attack by the Russians were to be seen, with little else but their masts above water. Between 7 and 8 A.M. on the 11th we arrived off *Churuk-Su.* Here there is no harbour such as Sinope possesses, but merely an open roadstead. About 10 o'clock, Selim Pacha, the Commander-in-chief, came on board under a salute, and a portion of the troops were disembarked, though, owing to the very heavy surf, for which that coast is famous, rendering it very hazardous to land, the remainder were obliged to remain on board until the following day.

At that time the garrison consisted of about 10,000 troops, including the irregulars, more generally known by the name* of Bashi Bazouks; but owing to the complete want of organization of the army, and the large amount of sickness, there could not have been more than one-third of this number effective.

The place consists only of a few houses forming a village, which was enclosed the whole way round by earthen intrenchments, of small profile, thrown up by the Turks immediately on their retreat. There were also some few batteries, looking sea-wards, one of which we were given to understand did good service in sinking a Russian war steamer which appeared off the coast a short time before.

Leading from Churuk-Su there are but two main roads, one to Ossurgheti, the other to Tenefetil, on the ancient boundary between Turkey and Russia. As one front is bounded by the sea, and the country around, except these two roads, is a complete marsh, the place may be considered very strong by nature.

The scenery of the coast at this point, with range above range of lofty snow peaked mountains in view, is grand beyond description.

On the night of the 14th we arrived at *Redout Kaleh*, expecting to find there an English man-of-war, but she had left a few hours before we arrived.

The town, which was built entirely of wood, had been completely destroyed, with the exception of the barracks and a few houses which had escaped being set fire to by the enemy, when forced to evacuate it. It is situated on both banks of the river Khopi, up which, by a road to Kutais, the principal trade of this district was carried on; and this river is joined by the Tsie, about 500 yards from the sea. There is a bar extending across the mouth of the river Khopi, and the channel is difficult and dangerous, even for small boats; but the river is deep opposite to the town. The roadstead is quite open and unprotected, and it is necessary for vessels drawing 12 feet water to anchor 2 miles out.

With the exception of the road leading along the banks of the Khopi, there was no route by which an army could possibly approach; the whole of the country in the vicinity of the town either consisting of an impassable marsh, or being thickly wooded, this place was, like Churuk-Su, very strong by nature. I found on my arrival here that some works had been hastily thrown up round the barracks, which stand on the left bank of the Khopi, and close to the sea, under the direction of Lieutenant Cox, Royal Marine Artillery, who was on board one of our men-of-war. I took advantage of them, making a few alterations in their trace, and by constructing a few additional works the place was soon rendered very strong. The Turks, and occasionally some of our seamen, were employed on them, principally in thickening and revetting the parapets, cutting wet ditches all round the works, so as to form a continuous enclosure, cutting embrasures, and laying platforms. As no wheel barrows were to be had, the whole of the sods for revetting the parapets were carried by hand, thereby trebling the labour.

The work round the barracks consisted of earthen parapets, having a wet ditch in front, flanked by small rounded bastions, each provided with a few embrasures; and a splinter-proof magazine was built in it, as well as a stockade at the south angle for preserving egress along the coast. Batteries were also constructed to command the junction of the rivers, about 400 yards in front, and to flank the approaches, and a chain was thrown across the river Tsie to stop the enemy's gunboats. Some time after I landed here, the English steam sloop "Wasp," commanded by Lord John Hay, arrived on the coast, and agreeably to instructions from the Admiral, I was received on board of her, and went in her to various other stations along the coast to strengthen the works there, in the same manner as at Redout Kaleh. Lord John Hay and the officers on board rendered me every assistance in carrying on the works. The sailors were landed, the ship's carpenters were employed in making the platforms, and even some of the officers themselves aided in tracing out the works.

On the 6th of August we went to *Soukum Kaleh;* Sefia Pacha was then the governor, and the garrison consisted only of 800 men.

The bay here forms an excellent and well sheltered harbour, and it is here that the Russian fleet, previous to the war, used to lie at anchor during the winter months. There is here an old Genoese citadel which mounts a few heavy guns, but with the exception of that and an earthen battery of 8 or 10 guns, which is well constructed and concealed from view, close to the beach, there is nothing to defend the place on the sea front. About three-quarters of a mile inland is a high plateau, which completely commands it, and which, from its very elevated position, might, with the addition of a ditch cut round it, form a good place of retreat. But with a garrison of only 800 men, 500 of whom were "hors de combat," it was a difficult matter to get anything more done than what was actually necessary at the moment. The mountainous nature of the country at this spot forms however a formidable, or I may say, almost impassable barrier against all but mountain tribes.

Our time was spent here principally in laying platforms, and repairing such batteries as existed.

On the 17th we went to Anaklia, having ascertained that some of the Abasians were conveying supplies to the enemy by boats. A small party of marines and sailors, with a field piece, were landed on the beach, and they took possession of one or two of the boats without resistance.

From all we could learn, the Russians suffered from want of salt more than anything else along this coast, and to secure supplies of this, silks, &c., of ten times its value were given in exchange.

We returned from hence to Redout Kaleh, and found there Sergeant Marshall and Private Richards, Royal Sappers and Miners.

A small body of Russian cavalry had come down to our works on the 17th August, to reconnoitre our position, but having received a few rounds from our guns, quickly dispersed.

We found that the enemy had been throwing up some earthworks on the banks of the river, about three miles from the town, evidently in anticipation of being attacked.

Hearing of this, we were naturally anxious to march up and dislodge the enemy. Lord John Hay volunteered the services of his boats and men; but in consequence of the very reduced state of the garrison, and our orders to act only on the defensive, the project was abandoned. The garrison at this time was so small, that finding a Russian force so close to us, and probably quite prepared to act on the offensive as well as defensive, Lord John Hay offered to go down to Churuk-Su and bring up reinforcements. We accordingly steamed down on the 22nd to obtain them from the Commander-in-Chief, Selim Pacha, who however we found had been suddenly recalled, and had left for Constantinople. From the General next in command, however, we received on the following day a reinforcement of 421 men, including Bashi Bazouks, besides a supply of 200,000 rounds of ammunition. These were immediately embarked, and landed at Redout Kaleh on the following morning.

From this date, up to the time of the detachment leaving for the Crimea, in October, nothing of importance occurred. Privates James Waddell and Samuel Corrigan, R.S. and M., joined me at Redout Kaleh, on the 25th of August, and the remaining portion of the time was spent at the different forts, as circumstances required, in adding to the defensive works.

PAPER XVIII.

Remarks on the Protection of Wood from Fire,

By F. A. Abel, Esq.,

Chemist to the War Department,

Accompanied by a Report on Experiments made at Chatham,

By Colonel Sandham, R.E., and himself.

The attention of practical men has been for some years past directed, from time to time, to the importance of affording to wooden erections some degree of protection from the effects of fire; and numerous plans have been proposed, and to some extent tested, for lessening the combustibility of wood, and for covering its surface with a protective coating more or less unalterable by fire.

The simple application of lime or clay-wash, for example, has been found to afford some slight protection to wood, although the tendency of such materials to peel off the surface of the wood (into which they do not in any way penetrate), by exposure to heat, and the rapidity with which the coating is destroyed by atmospheric influence, render them very ineffective agents.

Several processes have been patented, even recently, for the protection of wood from fire. Some idea of the general nature of such processes will be conveyed by the following extract from an official report made on this subject:—

" The importance of obtaining an effective method of reducing the combustibility of wood, or even of protecting its surface from fire, has led to an examination into some of the methods of accomplishing this, which have been lately patented, and of the general nature of which the following is a brief statement.

I.—" *Mr. Maugham's Patent* consists in saturating dried wood with an aqueous solution of phosphate of soda and muriate or sulphate of ammonia, in certain proportions.

" It is believed by the patentee that these salts will be so affected by each other, and by the action of heat, that the fibres of the wood will be protected by an incombustible coating, while a quantity of vapour will be generated by the volatilisation, and partial decomposition, of the ammoniacal salts, which will possess the power of extinguishing flame.

" The same objects are believed to be obtained by—

II.—" *Lieutenant Jackson's Patent Process,* by which wood is impregnated with a solution of salts of zinc and of ammonia.

" The same means are adopted in both of these processes for saturating the wood.

" It is packed into large cylinders from which the air is then exhausted, the liquid being afterwards forced in with a pressure of 150 to 200 lbs., which is maintained during one or two hours. It is the same method as that employed in patent processes for preserving timber from decay.

" I am not aware whether Mr. Maugham's process has been submitted to any extensive practical test. Numerous experiments were however instituted on Lieutenant Jackson's process, under the direction of Mr. Brunel.

" Specimens of seventeen different kinds of wood were prepared ; corresponding pieces being kept unprepared, and others covered with a coating of paint. Their powers of resisting fire were tested by piling the prepared, unprepared, and painted specimens round a perforated sheet iron surface, filled to the top with a bright coke fire.

" In most cases the prepared wood resisted the action of fire for a longer period, and, when removed from the fire, ceased burning sooner than the unprepared specimens.

"It was also evident that light porous woods were more efficiently protected than those of a denser character.

" There is no doubt therefore that the combustibility of wood is more or less diminished by either of the above methods of treatment, although the protective action must be ascribed to the indestructible compounds with which the wood is to some extent impregnated, far more than to the vapours evolved by the decomposition of the small quantities of ammoniacal salts forced into the wood.

" Although by the impregnating process adopted in the above patents, the preparative solution is believed to be forced into the very centre of the wood, it is essential, if such a result is to be obtained, that the solution should be weak, since it is impossible to force strong saline solutions thoroughly into wood.

" It is evident that the protective action of the salt cannot, under these circumstances, be very powerful.

" Were it possible, on the other hand, to employ stronger solutions, the expense of the processes would be considerable.

" The necessity of costly apparatus for impregnating the wood is also a matter of serious moment."

The patentees of some of the wood-preserving processes go so far as to state that they are enabled to render wood incombustible or uninflammable, and such statements have tended to lead to the presumption that a thoroughly effective protecting agent should have the power of depriving wood of its combustibility.

It will be readily understood, however, that even if a piece of wood could be most thoroughly impregnated with a solution of some strength, of matter unalterable, or at any rate only fusible, by continued exposure to heat, the amount of protective material thus deposited in the pores of the wood, although it might be considered to surround each particle of fibre, would not prevent the destructive distillation of the wood by the effect of heat, the result of which would be the disengagement of inflammable vapours from the wood, and its ultimate complete ignition, if maintained for a sufficient period in the vicinity of highly heated or burning matter; or, if on the other hand, the protective agent employed be convertible by heat into vapours possessing the property of extinguishing such fire as they may completely surround, such vapours might have the effect of partially or completely extinguishing the fire in a piece of ignited wood, *after* its removal from the source of heat or fire, but otherwise the volume of vapour generated from the preparation used, would be but slight, as compared with the inflammable vapours evolved from the over-heated wood, and would have no perceptible effect on the combustion of these, while the scorched, or charred, woody fibre would be less efficiently shielded from the effect of flame than by the coating formed from an indestructible preparation.

It does not therefore appear reasonable to expect more from the most efficient protective coating or impregnating material than—

1st. That it should considerably retard the ignition of wood, exposed for some length of time to the effect of a high temperature, or of burning matter in its immediate vicinity.

2nd. That if the vapours which the wood will emit, by continued exposure to heat, become ignited, the flames thus produced shall not readily affect the fibre of the wood, and shall cease almost directly on the removal of the wood from the source of heat; and

3rd. That prepared surfaces of wood, when in actual contact with burning unprepared wood, shall have little tendency to ignite, and thereby cause the fire to spread.

In addition to such processes as those above referred to, in which the protecting material is forced into the wood by the application of considerable pressure, trials have been made with agents of different kinds, in solutions or baths, in which the wood was steeped, or allowed to soak, for some hours, so that it might be in a slight degree impregnated with the material, or that a superficial coating of the protective might, at least, be formed.

Some of these methods have been made the subject of experiments by order of Lord Panmure, with a view to test their merits.

One, proposed by W. C. Salomons, of Paris, consisted in immersing the dried wood, alternately, in two baths; the one containing three parts of acid sulphate of alumina, and one part of glue, dissolved in six parts of water; the other consisting of two parts of dry chloride of calcium, one part of glue, and seven parts of water.

The objects which the inventor wishes to attain, by the use of these solutions, are, firstly, to impregnate the wood slightly with one of the salts (the chloride of calcium, for example), and then, by immersion of the wood in the second bath, to effect the decomposition of the first salt by the second, in the pores of the wood.

Thus the chloride of calcium and sulphate of alumina should become converted into sulphate of lime, and chloride of aluminum; the former an almost insoluble substance, the latter a soluble deliquescent body, possessing the property of converting the glue employed, together with the salts, into an insoluble body—a species of leather.

The pores of the wooden surfaces are therefore, by the treatment in question, to be filled up by particles of a substance nearly insoluble, and unalterable by heat, which, together with the soluble salt, also present, are to be protected and united by means of the precipitated glue, which dries up to a hard, horny substance.

The experiments made with this process showed that the glue employed in the solutions greatly impeded the penetration of the wood by the saline matter, and also caused the decomposition of the salts to be very partial.

The protective property of the coating formed on the wood, prepared by this process, was not found to be considerable, while the expense of the materials was great, as compared with others equally efficient.

The successful results obtained on the Continent by the application of alkaline silicates, as protective materials, led to an examination into the comparative value of the cheapest of these, the soluble silicate of soda, as an agent for decreasing the combustibility of wood.

The property possessed by the soluble alkaline silicates, of being readily softened by hot water, and thus converted into a state of solution, while they are but slightly affected by cold water, renders their application to wood, either in the form of a bath, or as a wash, very simple. Their dilute solutions being readily absorbed by wood, the surfaces of the latter, as it dries, assume the form of a hard coating.

The experiments made in the first instance with the silicate of soda, and the results obtained, are described in the following extract from the official report:—

"Various specimens of dry wood were prepared with silicate of soda, by being soaked for a few hours in a weak solution.

"Upon examining the interior of these, after the removal from the bath and subsequent desiccation, the silicate was found to have penetrated about a quarter of an inch on all sides.

On piling the above over a fire, together with specimens of unprepared wood, and others that had been prepared by different processes, the superiority of the silicate of soda, as a protective agent, was fully established.

"Some specimens of wood were then simply painted with a moderately strong solution of silicate, and afterwards placed, together with unprepared wood, in a pool of coal-tar naphtha, some of the latter being thrown over the surfaces of the wood.

"Immediately on the ignition of the naphtha, the wood was surrounded by flames, which soon fired the unprepared pieces, whilst those coated with the silicate only ignited after a time *at the edge*, and were scorched or baked by the heat, but not burned.

"A wooden hut, similar in construction to those at Aldershot, having been erected in Woolwich Marshes, for the purpose of testing the value of Phillips's Fire Annihilator, advantage was taken of the opportunity thus offered for trying, to some extent, upon a larger scale, the merits of the silicate as a protective.

"Shortly before the experiment took place, an application was made to me, by the officers of Royal Engineers, for the preparation, in some way, of a portion of the building with a protective agent.

"One part was painted, inside and out, with a mixture of lime and alum, which, however, was not found upon experiment to act as an efficient protective against fire.

"Another part of the hut was painted, inside and out, three times, with a solution of silicate of soda.

"Unfortunately for the fairness of the experiment, the building was constructed with a double boarding, so that it was only possible to coat or impregnate the planks on one side. Nevertheless, the value of this agent was established beyond doubt.

"A large heap of shavings was lighted in the interior of the hut, against the coated portion of the wall. The flames played fiercely upon the latter for some minutes, but only succeeded in kindling one edge of a plank, and that portion did not blaze, but smouldered for a short time.

"By the heat of the fire, the salt was drawn to the surface of the wood, and fused, forming a glazing upon it.

"Subsequently, when the whole building was destroyed by fire, after unsuccessful attempts to extinguish it by means of the "Annihilators," the fierceness of the flames was such, that few materials could have withstood it; yet, of the exterior, coated, portion of timber, several planks remained.

"Upon examining these, the unprotected surfaces which had been directly exposed to the fire were found to be completely charred, but this charring had extended only to the point to which the silicate had penetrated from the other side of the plank.

"This experiment is considered to have proved that the silicate of soda is a very valuable protective agent, and that, even when simply applied as a paint, it will serve to protect wood for a considerable time from fire, and to retard greatly the spreading of a conflagration."

Shortly after the experiments above described were made, the possibility suggested itself of rendering the coating of silicate less destructible by exposure to wet, of increasing its efficiency as a protective, and of rendering its application more economical, by combining with its use that of ordinary lime-wash.

Some pieces of plank were prepared in the following manner ; a dilute solution of the silicate of soda was first applied with a brush ; when this had thoroughly soaked into the wood, and dried, a thick lime-wash (made by slaking some lime, and reducing the hydrate to a smooth wash of the consistence of thick cream) was applied, and lastly, after the planks had been exposed to the air for two or three hours, they were painted with a second solution of silicate of soda, somewhat stronger than that first used.

The effects of the liquids thus applied, both upon the wood and on each other, will be more particularly pointed out in a report subjoined.

Several experiments, precisely similar to those described below, were made with the prepared planks, the results proving most satisfactorily that the protective coating resisted to a remarkable degree the action of heat, evinced no symptom of peeling off the highly heated surface of the wood, and protected the fibre to a great degree from the influence of flame playing upon its surface.

The durability of the coating was tested by exposing prepared surfaces of wood to a continuous stream of water, and to heavy rains, for a considerable period. It was found that the rain had no effect upon the coating; in the other more severe test, the material was only to some extent removed, after a time, on that spot where the jet of water first impinged upon the wood.

A trial was made of the firmness of the coating, by applying heavy blows to the surface of the wood ; the covering was only disturbed in one or two places, where the lime had been laid on rather too thickly.

Upon the results of these experiments being reported, an order was issued by Lord Panmure to have the proposed process for the protection of wood from fire, practically tested at some of the camps or stations.

It was ultimately arranged that a proper trial of the process should be instituted at Chatham, under the direction of Colonel Sandham, R.E.

The nature of the experiments performed at Chatham, and the results obtained, are detailed in the following official report:—

Report on Experiments at Chatham,

From Colonel Sandham, R.E., and F. A. Abel, Esq., to the Inspector-General of Fortifications.

Sir,

We have the honor to inform you that some experiments with silicate of soda applied in conjunction with lime-wash, as a means of protecting wood from fire, and of retarding its combustibility, have been made at Chatham, on a sufficient scale to determine practically the value of this agent, if applied as a preservative to camp-huts.

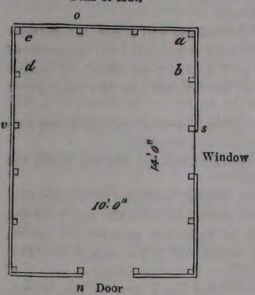
The following is an account of these experiments, and of the results obtained.

A small single-boarded hut was built in the Model Battery, the material used in its construction being of the description usually employed for camp huts.

It was provided with one door, and a window-opening on one side, closed by a shutter.*

After the hut was completed, certain portions of it were prepared, on the 8th and 9th of January, with the silicate of soda in the following manner:—

Plan of Hut.



1st. The wood was washed over with a somewhat dilute solution of the silicate of soda, applied in the manner usually adopted for whitewashing walls.

2nd. After an interval of about two hours, a coating of thick lime-wash was applied, over that of the silicate.

3rd. On the following day the prepared portions of the interior of the hut received, upon the lime, a second application of the solution of silicate of soda, a little stronger than that first applied.

Shortly afterwards the exterior prepared portion of the hut was similarly coated with the silicate.

The prepared wood therefore received,—

1st. A coating of dilute silicate of soda, which penetrated slightly into the wood, generally to the depth of about $\frac{1}{10}$ inch.

2nd. A coating of thin lime-wash, and

3rd. A second coating of silicate of soda, which, acting chemically upon the lime, formed a hard protective coating with the latter on the wood.

Two opposite corners of the hut, with about one-third of each side, and a corresponding portion of the roof, were left unprotected.

One side of one of the unprotected corners of the hut received three coats of paint; a similar coating was applied, over the protective coating, to one side of a prepared corner.

Some pieces of plank were also prepared with the silicate of soda, and lime, as described above.

Experiments with the prepared hut were unavoidably deferred until the 12th of February, 1856. During the interval the hut had been repeatedly exposed to very heavy rains; but although the light wood of which it was constructed was eventually completely saturated with wet, the coating on the wood was not in the slightest degree injured, and could be removed, by knocking the wood, only in one or two places in the roof, where the surface of the boards was very rough, and the coating consequently less perfect.

* The hut was 14 feet by 10 feet, 6 feet high at eaves, and 9 feet at ridge; it was constructed of $\frac{3}{4}$-inch deal weather boarding, on quarters and rafters of deal, 3 in. by 2 in. Door, 6 feet 6 inches by 2 feet 9 inches, of 1 inch deal, and window 3 feet by 2 feet, closed by a shutter of 1 inch deal. Floor of 1 inch deal, on fir joists, 4 inches by 2 inches, the upper surface of floor being 6 inches above the ground. Both sides of the walls from *o* to *s*, and from *v* to *n*, were prepared. The insides of the portions *a b*, *c d* were painted with common oil paint in three coats, that at *a b* being laid on the prepared part, while that at *c d* was laid on the unprepared part.

Experiment 1.

A fire of wood, charcoal, and coke was kindled in a tall iron stove provided with numerous large openings in the sides, so as to admit of a greater escape of heat in the neighbourhood of the boards.

The stove was placed in a prepared corner of the hut, at a distance of about 10 inches from the sides, and the fire was speedily raised to a sufficient degree to render the sides of the stove red hot in several places.

About one hour and a quarter elapsed, after the stove was well alight, before those portions of the sides nearest to the hottest parts of the fire evinced any symptom of igniting, although the wood was scorched, and to a great extent baked, in several places, those portions becoming at last so hot on the outside that the hand could scarcely be placed against them.

At this point the prepared side which had been painted, became ignited, the vapours emitted from it, by the baking of the wood, being very considerable.

The remainder of the heated corner inflamed instantaneously, but the flame was not so powerful as that covering the painted portion.

After the first burst of flame from the prepared planks, produced by the ignition of the vapours baked out of the wood, the fire went down considerably and made but very little progress. Now and then a small burst of flame was seen on the outside, issuing from between the joints of the weather-boarding, but it was soon evident that the fire could only with great difficulty seize permanently on the prepared surface of the wood, and that it only spread very slowly by creeping along between the overlapping portions of the planking, which were unprotected, and between the quarterings and the planks, where the surfaces of the wood could not be reached by the brush in the process of preparation.

Some pieces of plank, which had been piled against the stove in the building, having become inflamed, as also a small portion of the flooring, which was not prepared, a pail of water was thrown, from the doorway, at the stove, whereby the fire from the planks was extinguished; the water, however, scarcely reached the sides of the hut and did not affect the fire in the stove.

About an hour after the corner of the hut had been kindled, the stove, which had some time before partly fallen from some of its supports, so that it actually leaned against one side of the hut, protruded from the opening ultimately formed in the corner by the fire, which, though not interfered with, had confined itself almost to the immediate vicinity of the highly heated stove.

The latter was now removed from the hut through this opening, and a short time after, a little water was used to extinguish the fire which had been communicated to that part of floor over which the stove had been standing.

The fire which was burning here and there very slowly, in the corner of the hut, was left untouched.

Experiment 2.

Soon after the experiment above described had been commenced, and before the fire in the stove had produced any effect upon the hut, a pile of shavings and wood, with a little tar, was made in the opposite prepared corner of the hut, upon some loose prepared planks (laid down to save the unprepared flooring of the hut), and, this having been kindled, a fierce fire was maintained for about ten minutes; the flames licking the sides of the hut and a portion of the roofing.

At the expiration of that time, the sides and upper corner of the hut were perceived to be burning in a few places, at the edges of the weather-boarding. A short time afterwards the pile of fire was withdrawn, upon which the prepared surfaces of the wood immediately ceased burning, and it was found that the fire had only to a slight extent seized permanent hold of the corner, in three places.

1st. At the bottom, at the overlapping portions of two planks: the fire was soon extinguished spontaneously at this point.

2nd. About half-way up the corner between the back of the quartering and the weather-boarding, where the fire continued to smoulder on, consuming the unprepared portion of the wood in that spot.

3rd. In the upper corner, immediately under the roofing. At this spot there was necessarily a considerable portion of wood (the backs of the joists, wall plates, and planking) which could not be reached by the preparation, and which therefore served as a hold for the fire.

It was interesting to observe how in this, as in the experiment first detailed, the fire slowly crept along those small portions of wood which had escaped preparation, in the protected corners, (*i. e.*, the overlapping edges of the weather-boarding, and the backs of the quarterings); while the prepared surfaces of wood exhibited no tendency to carry the fire along, and were only consumed when in contact with other burning matter, or when surrounded for a length of time by flame from unprotected portions of the wood.

Although, at the expiration of about three hours, portions of the two opposite corners of the hut were still burning; and frequent gusts of wind served to fan the fire, it was found that the hut could be left, without fear of the fire spreading so as to become unmanageable.

Upon our returning to the hut, after the lapse of about half an hour, the fire was still found smouldering here and there in both corners, having extended very little farther along the unprotected portions of the wood, as above described, particularly between three of the joists, and in the corner immediately under the roofing.

The effects of the fire were watched for a short time longer, and the few burning places in the prepared corners were then extinguished by the application of a little water from a mop.

The above experiments showed that, although the attempts to kindle the protected corners of the hut had ultimately succeeded, in one instance, by the maintenance of a fierce fire for several minutes against the wood, and in the other by the immediate vicinity, and even actual contact, of a highly heated stove with the wood, for a great length of time—

1st. The prepared surfaces of wood, having been thoroughly baked, only burned as long as they were in close contact with burning, or highly heated matter, or for an instant when exposed to a powerful current of air; and did not possess any tendency to lead the fire along, this being only effected by the unprepared portion of the wood :

2nd. At any period during the four hours, for which time the fire was allowed to exert its uncontrolled effect upon the prepared portions of the hut, the burning parts of the building could have been with ease extinguished, by means of a couple of pails of water.

Experiment 3.

While the experiments with the hut were being carried on, some pieces of prepared and of unprepared planking were piled together in two similar heaps in the open air, and a fire of shavings and wood-chips was made up under them.

The comparative tardiness with which the prepared planks inflamed, and the difference in time required to effect the actual ignition of these and that of the unprepared planks was very evident, as was also the case with pieces of planks which had been piled up against the sides of the stoves in the building.

The prepared boards upon which the fire had been kept up in the corner of the hut were also examined, and found to be but little affected by their protracted contact with burning matter.

The wood had only caught at the edges, and was found smouldering there in two or three places.

By submitting the glimmering portion to the blast of a bellows, a small flame was produced, which went out immediately on the removal of the current of air.

Experiment 4.

In order to have convincing proof of the advantages of the preparation in retarding the ignition of wood, it was resolved to make experiments, similar to those described as Nos. 1 and 2; to observe the difference in time required for the ignition of the wood in the unprepared corners of the hut, and to ascertain the comparative power of the fire to extend, in these parts.

A fire was kindled in the stove placed in one of the unprotected corners of the hut.

In about ten minutes after the stove had become thoroughly heated, the sides of the hut burst into flames, which at once rose to the roofing above, and kindled portions of it.

A heap of wood and shavings was lighted in the opposite unprepared corner, and in two or three minutes this portion of the hut was in flames.

The unprepared wood having been once kindled, the fire spread so rapidly as to be quite unmanageable in a few minutes, the flames completely filling the interior of the hut. But even under these circumstances, when the intense heat and fierce flames from the burning portions soon spread the fire to the prepared parts of the hut, it was remarkable how the flame crept along between the crevices and overlapping portions of the planks where the wood was unprepared, so that the prepared surfaces were always thoroughly surrounded by flame for a considerable time before they ignited. Some portions of the prepared planking, of which the wood had probably imbibed a rather larger quantity of silicate, in consequence of its greater porosity, offered great resistance to the fire to the very last.

We consider the experiments above detailed to have afforded conclusive proof, on a practical scale, of the considerable power possessed by silicate of soda, applied simply as a coating, in conjunction with lime, of retarding the inflammability of wood.

It is, of course, impossible, even by the thorough impregnation of wood with various substances, to deprive it of the property of burning; the only results to be attained by the use of a protective material are—

1st. To shield the substance of the wood itself in a great degree from the effects of neighbouring fire, or of the vapours which will issue from over-heated wood, and burn on its surface, and—

2nd. To deprive the wood, to a considerable extent, of the power of carrying the fire along, thus rendering necessary the *continued application* of heat or fire from another source (such as an over-heated stove or unprotected portions of wood) in order to effect its thorough ignition.

An examination of the experiments just described will show that these results are obtained by the application of the silicate of soda to the wood.

This substance may be obtained in any quantity at a very reasonable rate, and the method of applying it is so simple, that the wood may be properly prepared with it by ordinary workmen.

It appears to us important that, if its application to new camp huts should be determined upon, the wood to be employed in their structure should be completely coated with the preparation, before the erection of the buildings, in order to give the latter a fair chance of resisting the action of fire, reaching the wood from any quarter.

But even in buildings already erected, it is of importance that those portions which are in any way liable to possible exposure to heat or fire (*e. g.* the portions in the vicinity of stoves), should receive the very considerable protection which would be afforded by the application of the silicate coating, any covering of paint or paper having first been removed.

We beg to give it as our opinion that the efficiency of the protective agent in question has been sufficiently tested to obviate the necessity of further trials upon a large scale, and submit, in conclusion, that while the extensive employment of light wooden buildings for huts and temporary workshops, renders the application of some protective material to the *interior* of these, at any rate, a matter of great importance, it is of equal consequence that such an agent, if adopted for use in the service, should be easy of application and inexpensive, and that its employment should be as completely under the control of Government as that of any ordinary coating material.

We have the honor to be, Sir,
Your most obedient humble servants,
H. SANDHAM, Colonel, Royal Engineers.
Director Royal Engineer Establishment.

F. A. ABEL,
Chemist to the War Department.

March 1st, 1856.

The above report was accompanied by a communication relating to the cost of the application of the silicate coating, in which it was stated that, provided the silicate of soda employed has been prepared with especial reference to this application (*i e,* so as to be readily and completely misceable with water), one pound of the material is sufficient to prepare a surface of wood of ten square feet; while the wholesale price of the silicate, in the form of a syrup of a certain degree of concentration, is twenty pounds per ton; so that the cost of the silicate required to prepare the wood, is at the rate of about two-pence for a surface of ten square feet.

Experiments are just now being carried on, with a view to impart to the silicate-coating the appearance of paint, by combining the use of different colouring matters with that of the lime.

The following are the directions adopted for general guidance, in preparing wood with the coating of silicate of soda, and lime.

Directions for Covering Timber with a Protective Coating of the Silicate of Soda, and Lime.

Materials employed.—The silicate of soda must be in the form of a thick syrup, of a known degree of concentration, as manufactured by Messrs. Simpson and Co., Kennington Road, London.

The lime-wash should be made by slaking some good fat lime, rubbing it down with water until perfectly smooth, and then diluting it to the consistency of thick cream.

Treatment of the Wood.—The protective coating is produced by painting the wood, firstly with a dilute solution of silicate of soda; secondly, with the lime-wash; and lastly, with a somewhat stronger solution of the silicate.

The surface of the wood should be moderately smooth, and any covering of paper, paint, or other material should be first removed entirely, by planing or scraping.

A solution of the silicate, in the proportion of one part by measure of the syrup to three parts of water, is prepared in a tub, pail, or earthen vessel, by simply stirring the measured proportion of the silicate with the water, until complete mixture is effected.

The wood is then washed over with this liquid, by means of an ordinary white-wash brush, the latter being passed two or three times over the surface, so that the wood may absorb as much of the solution as possible. When this first coating is nearly dry, the wood is painted with the lime-wash in the usual manner.

A solution of the silicate, in the proportion of two parts by measure of the syrup to three parts of water, is then made; and a sufficient time having been allowed to elapse for the wood to become moderately dry, this liquid is applied, upon the lime, in the manner directed for the first coating. The preparation of the wood is then complete. If the lime-coating has been applied rather too thickly, the surface of the wood may be found, when quite dry, after the third coating, to give off a little lime when rubbed with the hand. In that case, it should be once more coated over with a solution of the silicate, of the strength prescribed for the second liquid.

PAPER XIX.

ON COAST DEFENCES.

By MAJOR GENERAL LEWIS, C.B., Royal Engineers.

Having hazarded an opinion (vide Professional Papers, New Series), that an army cannot make a successful debarkation, if it is met on shore, and the landing opposed, by an adequate force, I am anxious to shew that however successful were the operations of the allied forces in September, 1854, that success was based upon the mistakes of the Russian Commander-in-Chief.

Instead of it being the result of the skill or valour of the combined forces, who met with no opposition or difficulties, the success should be attributed to good fortune, which usually favors audacity, and the error committed by the Russian Chief, in abandoning the coast for a favorable position on the Alma River, to make a stand there for possession of the country, an error so often committed since the time when the Saxon Harold fought for the possession of his kingdom.

The combined forces were certainly as formidable as was possible in the advanced state of the art of war, aided by steam and heavy artillery, now brought into use, with the advantages of an open low shore and no opposition ; hence the successful result.

But, on the other hand, if the Russians had organized a defence, for which the nature of the ground, and the outline of the coast gave great facilities ; and if the heavy field artillery which accompanied their army, with a fair proportion of cavalry, had been distributed between Eupatoria and the mouth of the Alma ; considering the difficulties which generally occur upon an open coast, and which actually did occur,* of rough weather and a surf which impeded the completion of the landing, either the allied forces would have been repulsed, or the attempt would not have been made.

If the Russian army, supposed to have consisted of 40,000 to 50,000 men, had been distributed along the coast, in divisions of 3,000 men, leaving 2,000 men in Eupatoria, and a reserve from three to four miles in the rear ; and if the brigades had entrenched themselves on the beach, forming "emplacements" for their artillery, and epaulments for cavalry, had waited until the boats with the allied troops approached the shore, and then opened their fire, it is fair to calculate that the debarkation would have failed, or, if partially successful, that the reserve could have moved down and probably routed or destroyed the remainder of them.

Every thing was in favour of this plan of defence, the country was open, and permitted a retreat of the Russians under cover of their cavalry and artillery, should any

* See Appendix.

of the divisions be cut off by a successful landing of any part of the allies; and the coast to be defended was not more than twenty miles long, *i.e.*, from the Putrid Lake to the mouth of the Alma river.

But the error so often committed, of taking up a defensive position, thought to be impregnable, and there awaiting the issue, produced the result, of not only losing the battle, but of also causing the loss of the country which the army was destined to defend.

G. G. L.

APPENDIX.

Camp near the Old Fort,
September 18*th*, 1854.

MY LORD DUKE,

I do myself the honour to acquaint your Grace that the combined fleet and their convoys appeared in the Bay of Eupatoria on the 13th inst., and in the course of the following night proceeded some miles to the southward, where the allies commenced disembarking early in the morning of the 14th—the French in the bay below Old Fort, the English in the next bay nearer to Eupatoria; and before dark the whole of the British Infantry, some Artillery, and most of the French troops, were on shore.

Shortly before dark the weather unfortunately changed, and it became hazardous to attempt to continue landing either troops or guns.

The surf on the beach impeded the operation the following morning, and since, on more than on one occasion; but thanks to the exertions of the Navy, under the able and active superintendence of Rear Admiral Sir Edmund Lyons, who was charged with the whole arrangement, every obstacle has been overcome, and I am now enabled to report to your Grace that the disembarkation has been completed.

I should not do justice to my own feelings, or to those of the troops I have the honor to command, if I did not prominently bring to the knowledge of your Grace the deep sense entertained by all of the invaluable services rendered by her Majesty's Navy.

The spirit by which officers and men were animated made them regardless of danger, of fatigue, and indeed, of every consideration but that of performing an arduous and important duty; and that duty they discharged to the admiration of all who had the good fortune to witness their unceasing efforts to land horses and carriages with the utmost expedition and safety, under, frequently, the most trying circumstances.

I have the honor to be, &c,.
(Signed) RAGLAN.

His Grace the Duke of Newcastle.

PAPER XX.

Notes on the Construction of Drawing Boards, especially adapted to Hot Climates.

By SAMUEL B. HOWLETT, Esq.,

Chief Draughtsman in the Office of the Inspector General of Fortifications

Having many years ago been called upon, in the course of my duty as Inspector of Scientific Instruments, to supply some drawing boards for Africa, I found myself in a difficulty, as the demand was accompanied by a remark that all the boards that had been sent out, or made there, soon split and warped, and became useless.

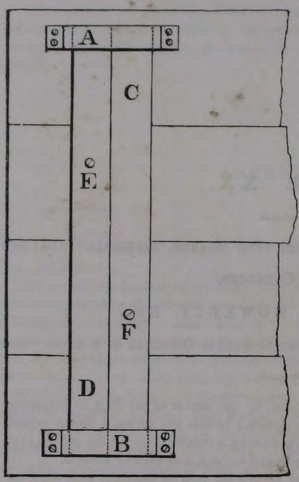
As all wood will shrink laterally, I set myself the task of making, with my own hands, a model board that would leave the wood free to contract or expand in the hottest climate, and at the same time be firmly and sufficiently held down to clamps of wood across the back.

To prove the board I made, I all but burnt it before a fire for many days; and being sure that the principle of construction was good, I ordered boards to be made like it; and was informed many years afterwards that they kept their figure perfectly, in defiance of the heat of the torrid zone.

Six months ago, I was, in like manner, called upon to supply ten boards of the sizes of large drawing-paper, upon which works, for which it will take half a million to pay, have already been schemed; as these boards have been found to answer perfectly, and are generally liked, and also on account of the novelty of the principle, a description of the construction may probably be considered worthy of a place in the Royal Engineer Professional Papers.

The boards in question are made of good seasoned pine, about ¾-inch thick, without knots, planed smooth and true, as usual; the joints of some of them are simply glued together, and others are grooved and tongued.

The diagram shows one end of the back of one of these boards, and of course the other end is similar.



A and B are iron straps (which, in making the model, I bent into form out of hoop-iron), and these are screwed to the board very securely, at about $\frac{1}{2}$ inch from the edge. These straps should be smooth at the corners, so as not to injure the table.

C and D are two pieces of straight wood, about $\frac{3}{4}$ inch thick, made so as to slide rather tightly through the straps, but not so tightly as that they will not move freely with a little pressure.

At the points E and F, the cross-pieces, or clamps, C and D, are screwed immovably to the board, at distances obtained by dividing the length of the pieces into three equal parts.

All this is very simple indeed, but simple as it is, we see that the board at each end is held to the cross clamps at four points, and yet, at the same time, the wood is left free to shrink or expand. We see that, instead of trying to force the wood to accommodate us, we have, in this arrangement, accommodated ourselves to the wood, and gained exactly what we really wanted.

I have just examined one of these ten boards. It has shrunk half an inch in the whole width, causing one end of the piece C to obtrude two-thirds of this length beyond the strap A, and the other end to obtrude the other third of it beyond the strap B; and, in like manner, the ends of the cross-piece D obtrude beyond the straps, only in contrary directions to the other piece.

Notwithstanding the shrinking, these large boards are accurately true, as proved by placing a straight edge across in any direction, and trying them by a square.

S. HOWLETT.

Office of Ordnance,
Pall Mall, 28th September, 1855.

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