PAPERS

ON SUBJECTS CONNECTED WITH

THE DUTIES

OF THE

CORPS OF ROYAL ENGINEERS,

CONTRIBUTED BY

OFFICERS OF THE ROYAL ENGINEERS.

NEW SERIES.

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TABLE OF ERRATA.

Page 25, line 38, for "Winconsin," read "Wisconsin."

„ 34 „ 18, for "Fort Garry," read "Ottawa."

„ 34 „ 21, for "11 officers, 80 men, and 180 horses or oxen," read "12 officers, 80 men, and 294 horses or oxen."

„ 41 „ 16, for "40 oz." read "48 oz."

„ 43 „ 5, for "Assinebonies," read "Assineboines."

„ 44 „ 9, „ „

„ 57 „ 22, for "2 D," read "Z D."

„ 59, add initials "A.F." at bottom of page.

„ 66, Table VI., for "Tip circle," read "Dip circle."

PREFACE.

The Editor has to apologise to the Subscribers for the delay which has occurred in issuing the present Volume, which will be the last of the series of the "Professional Papers" in their present form. The Volume was ready some time since, with the exception of the last Paper (on the Ashantee Expedition), the official sanction for the publication of which was only recently procured; and without this Paper it was conceived that the Volume would have been looked upon as incomplete.

In resigning his post, the Editor desires to thank his brother officers for the kind way in which they have overlooked the shortcomings of which he has been conscious; and he feels confident that under the auspices of the Royal Engineer Institute, the "Professional Papers" will, in their new form, have a long and prosperous career.

C. S. HUTCHINSON,
Colonel, Royal Engineers,
Editor.

Railway Department,
Board of Trade, Whitehall,
September, 1876.

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PROFESSIONAL PAPERS.

PAPER I.

THE AMERICAN FLAT FIRE PROOF ASPHALTED OR TARRED ROOFING, APPLICABLE TO COMMON BUILDINGS, EITHER TEMPORARY OR PERMANENT.

By Lieut. Colonel F. E. COX, R.E.

1. The roofing to be described has been largely used in North America for many years, and has been perfectly successful. The writer of this paper lived in a house so roofed in St. John's, New Brunswick, for four winters, and though the snow storms are heavy there, and the temperature very variable through the winter, no leak or inconvenience of any kind occurred; whereas during one winter passed in a house roofed with slates, at the ordinary pitch, an obstruction from icicles in one of the valleys, caused great inconvenience and discomfort in a sudden thaw.

2. The first point to be attended to is the pitch, which must not vary much from 1 in 12, an inch to the foot is easy to remember, and perhaps about the best slope; a slight variation either way is, however, admissible.

3. The roof must be stiff, as with so flat a pitch it is obvious anything like sagging must be guarded against.

4. The rafters and boarding are laid as usual; a layer of asphalted paper (which is made for the purpose in America, and is in itself a very light material, much less strong than the thinnest felt used in this country), or thin felt is then laid in strips overlapping a few inches (3 or 4), the first strip is carefully turned over the eave and securely nailed along the edge; the succeeding strips where they overlap each other should be tacked down as lightly as possible, only just sufficiently to keep the material in place during the subsequent operation.

5. The fire proof condition of the roof is obtained by superimposing on the asphalted or tarred surface, a layer of clean hot shingle of the uniform size of a Dutch marble; the shingle may be heated in an old asphalte cauldron, or by lighting a fire under a piece of sheet iron, bent into the shape of a waggon roof, the shingle being placed over the iron.

6. The asphalte is fluxed with a good deal of tar, so that it can be poured on; a certain amount of practical knowledge is required to ascertain the proper degree of fluidity, which is pretty much that of tar as ordinarily applied in this country. The asphalte is *not* spread as in the manner familiar to all who have

been engaged in the defensive works erected in the united kingdom of late years, but is simply poured on the roof with a ladle.

7. The asphalte being ready, and a plentiful supply of heated shingle also ready, the latter is piled up in a ridge all alongside and parallel to the strip to be coated, working down from the highest part of the roof (to start with it may be piled on a board temporarily supported along the ridge, or where it would be if there were one), and the operator pours a ladle full of stuff (asphalte or tar) over the paper or felt in a band (usually working from right to left), about a foot wide, and as long as his ladle full will allow. As soon as the fluid is on, he rakes down the warm shingle with a small iron rake, spreading it evenly over the asphalted surface, in which it becomes partially embedded and to which it adheres, the interstices being filled in with loose shingle. The surface should be completely covered about $\frac{3}{4}$ in. thick of shingle; the asphalting may be $\frac{1}{2}$ in. to $\frac{1}{4}$ in. thick in permanent buildings, and less in temporary buildings.

8. A fillet is nailed against the eave, projecting above it sufficiently to catch the liquid asphalte, which is brought flush with its upper edge; the eaves guttering is fixed against this fillet in the usual way.

9. The shingle should not be disturbed by walking on it. To obviate this light wooden foot gratings may be laid on the roof on top of the shingle. Walking on these foot gratings will not be detrimental to the roof.

10. Asphalted paper and asphalte are used in the American patent; but tarred felt, or paper and tar, are nearly if not quite as good, and thought preferable by some, as being cheaper in first cost, and less expensive in repair.

11. Skilled labour is not necessary; an intelligent labourer accustomed to apply tar could do the whole process; a certain amount of knack is required to run the asphalte on at a uniform thickness, and to rake over the shingle at once. This by an accustomed hand is done very readily. Three men are required, one to superintend boiling the asphalte and heating the shingle, and to hand up to a second, who passes it to the man on the roof, and takes back the empty ladle.

12. The pitch 1 in 12 is an indispensable condition. At a much flatter pitch hollows would be liable to form, and the water would lie; at a sharper pitch, the shingle would be apt to roll and expose the tar or asphalte, which, being affected by the sun, might thin out and occasion leaks, such as are constantly experienced in the high pitched tarred roofs common in England.

A roof laid as described, will certainly last for ten years without any need of repair; it is fire-proof by reason of the shingle; it is, of course, cooler in summer and warmer in winter than the common tarred roof. For temporary structures, such as huts, it gives a far better elevation, both for appearance and comfort; and not requiring the frequent tarring and sanding, is cheaper in the long run.

F. E. C.

PAPER II.

ON IMPACT.

By Lieut. T. ENGLISH, R.E.

In Paper IX., Vol. XIX., an attempt was made, in anticipation of direct experiment, to account for the energy absorbed in various ways when an armour plate is struck by a hard metal projectile; and from the results then found, curves were laid down, which represented the calculated ratios between the velocity of the projectile and the depth or thickness of armour penetrated or perforated.

A remarkable confirmation of the curve thus laid down, as representing the calculated penetration of the seven-inch gun, has been obtained by recent experiments, and appears worthy of record: especially as, since all the curves were deduced from the same assumptions, an experimental confirmation of one goes a long way to prove the correctness of the others, and to justify the dependence which has been placed upon them in determining the thickness of armour plates for War Department purposes.

Advantage has been taken of rounds fired at Shoeburyness, for the proof of armour plates during the past year, to obtain a series of twenty results, shewn by black circles in the diagram, Pl. I., annexed to this paper. All these results were obtained from the service seven-inch M.L.R. gun of seven tons, with service Palliser projectiles (1·5 D heads) and R.L.G. powder.

The velocities, for charges of from seven to twelve pounds inclusive, are taken from a table compiled by Captain (now Major) W. H. Noble, R.A., 9th Nov., 1868, O.S.C. minute 26,326; and for charges of less than seven pounds, the velocities are interpolated by the help of the same table.

All the velocities thus obtained are reduced in the proportion of 20 : 21, being that borne by the weight of the plate alone to the weight of the plate and projectile together, as explained in Paper IX., Vol. XIX.; and the velocities thus reduced are shewn as ordinates in the diagram.

The corresponding abscissæ are the measured penetrations.

The plain circle represents a round fired on 23rd June, 1868, and referred to in Paper IX., Vol. XIX.

The dotted line is the hyperbolic curve which represents the mean of the twenty-one results with the least probable error, as deduced by the method of least squares; and the continuous line, transcribed from the diagram accompanying Paper IX., Vol. XIX., gives the calculated curve for the seven-inch gun.

All the plates experimented upon were of good quality, and had been classed A in the Shoeburyness proof.

The following table gives, numerically, the results shewn in the diagram :—

Register number of plate.	Proof figure of merit of plate.	Register number of round.	Powder charge in lbs.	Muzzle velocity. Ft. per sec.	39 muzzle velocity. Ft. per sec.	Observed penetration in inches.	Mean of observed penetrations in inches.	Calculated penetration in inches.	Difference of observed from calculated penetration in inches.
3581	A_2	2140	3	340	320	2·90	2·40	2·6	—·20
,,	,,	2139	4	450	430	3·18	3·10	3·2	—·10
,,	,,	2137	5	565	540	3·55	3·70	3·9	—·20
,,	,,	2138	5	565	540	3·80	3·70	3·9	.....
4082	A_1	2136	6	675	640	3·95	4·30	4·5	—·20
,,	,,	2135	6	675	640	4·40	4·30	4·5	.....
4085	A_2	2134	7	781	740	3·95	4·90	5·0	—·10
,,	,,	2133	7	781	740	4·23	4·90	5·0	.....
4053	A_2	2150	7	781	740	5·15	4.90	5·0	.....
4072	A_2	2132	8	880	840	4·55	5·42	5·6	—·18
4098	A_2	2152	8	880	840	5·15	5·42	5·6	.....
4098	A_2	2151	8	880	840	5·20	5·42	5·6	.....
3568	A_2	2131	9	967	920	5·25	5·90	6·1	—·20
4053	A_2	2149	9	967	920	5·45	5·90	6·1	.....
4067	A_1	2130	10	1042	1000	6·65	6·33	6·5	—·17
4057	A_2	2148	10	1042	1000	7·10	6·33	6·5	.....
4089	A_2	2129	11	1108	1060	7·20	6·70	6·9	—·20
4057	A_2	2147	11	1108	1060	7·20	6·70	6·9	.....
4473	A_1	2153	12	1166	1110	7·00	7·00	7·2	—·20
3976	A_2	2146	12	1166	1110	7·40	7·00	7·2	.....
——	——	——	22	1413	——	8·45	8·70	8·9	—·20

From an inspection of the diagram or table, it appears to be approximately true that the depth of penetration varies as the striking velocity, and hence, if V be the striking velocity, and if s, v, p represent the depth penetrated, the

relative velocity, and the mutual pressure between the projectile and the plate at any instant, and if w be the weight of the projectile,

$$\int p\,d\,s = \frac{w}{2\,g}\ (V-v)^2$$

$$\int p\,d\,s = s^2 \quad \times \text{constant.}$$

$$p \quad = s \quad \times \text{constant.}$$

or, in words, the resistance developed by the plate at any instant varies as the depth of penetration, or as the relative velocity lost by the projectile up to that instant.

The ratio of pressure to velocity and space thus obtained, appears to be due to the circumstance, that by far the greater part of the resistance of an armour-plate is of a frictional nature, and uniform per unit of the surface in contact with the projectile.

The resistance is therefore analogous to the resistance to extension or compression of a material following Hooke's law of elasticity, *ut tensio sic vis*; in which case it was shewn, in Paper X., Vol. XVIII., that the maximum pressure produced by impact varies with the velocity.

A further confirmation of this ratio of pressure to velocity is to be found in experiments made in the Royal Arsenal on the compression of copper pellets, 0·5 inch long, and 0·083 of a square inch area, by statical pressure, and by the impact of a falling weight; when the results were obtained which are shewn in the following table, taken from the "Report of the Experiments conducted by the War Office Torpedo Committee during 1873."

Height of fall in inches.	Striking velocity in feet per second.	Calculated maximum pressure in tons (proportional to velocity.)	Compression in inches produced by corresponding statical pressure.	Observed compression in inches.	Difference of observed from calculated compression in inches.
54	17·0	3·79	0·224	0·222	+·002
48	16·0	3·57	0·212	0·208	+·004
42	15·0	3·35	0·199	0·194	+·005
36	13·9	3·10	0·184	0·179	+·005
30	12·7	2·83	0·166	0·163	+·003
24	11·3	2·57	0·148	0·144	+·004
18	9·8	2·19	0·120	0·121	—·001
12	8·0	1·80	0·091	0·094	—·003
6	5·7	1·29	0·053	0·060	—·007

A consideration of the foregoing results would seem to indicate that, as a

general rule in the cases of impact which usually occur in practice, the greatest mutual pressure will vary directly with the velocity lost by the striking body; the only important exception being when a ductile material is submitted to a tensile stress beyond its limit of elasticity.

For all cases except this, it is probable that an extension of Hooke's law might be stated in the terms, *ut velocitas, sic tensio, sic vis.*

T. E.

PAPER III.

ON THE WORKS CARRIED ON BY THE UNITED STATES GOVERNMENT FOR THE IMPROVEMENT OF EAST RIVER, NEW YORK.

By LIEUT. G. BARKER, R.E.

General description of locality.

The reef at Hallett's Point, measured along the ridge, projects into the channel at Hell Gate 300 feet from mean high water mark, and allows a draught of water over it, referred to mean low water mark, not exceeding 12 feet, from a distance from this shore of 270 feet.

Six hundred feet from the shore, and parallel to its western bank, lies a ridge of rocks known as Flood Rock.

Rate of current.

The rate of current in the vicinity of these rocks, which are situated in its full strength, is about ten miles an hour during a portion of the flood tide. (The maximum rate of current is during the flood tide.)

Vessels entering from the sea and passing up to the wharves are obliged to keep well away to the northern bank to avoid the Hallet's Point Rocks, and in this necessary precaution, lies the great danger to them. For by laying over to the northern bank to avoid the Hallett's Point Rocks, they get into the full strength of the current, which sets in the direction of Flood Rock, and are swept on to these reefs.

Object of works.

The object, therefore, for which these works have been undertaken, is to remove these sources of peril and to secure a draught of 25 to 26 feet of water at mean low water.

Flood Rock is also intended to be removed subsequently, to afford greater facilities for the passage of larger ships. A width of channel of 1,200 feet will be obtained when the whole of the work is completed. Some few other rocks lower down have also been removed.

The two operations, viz., that of removing the Hallet's Point Rocks, and that of

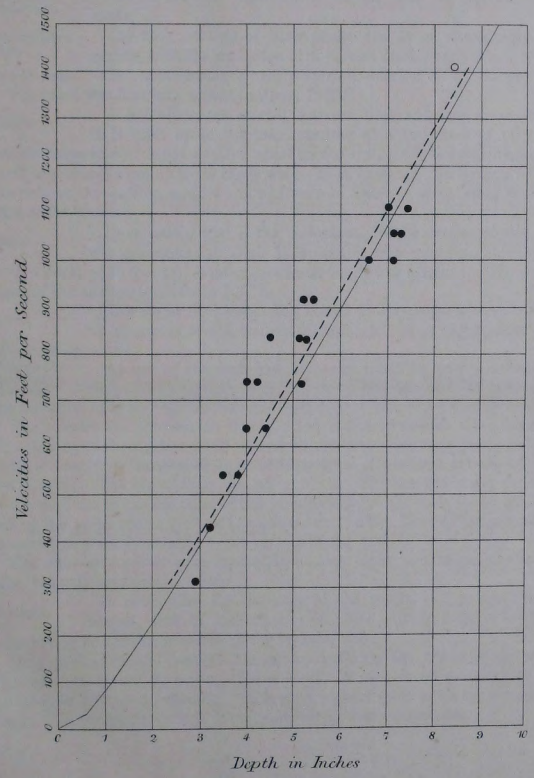
PENETRATION OF 7IN M.L.R. GUN

INTO ARMOUR PLATES.

● *Observed results 1875*

---- *Mean curve from observed results*

——— *Calculated curve from Paper IX, Vol. XIX. 1871.*



THOS KELL, LITH. 40, KING STREET, COVENT GARDEN.

breaking up the sunken rocks lower down the river, will be described separately, as the processes employed are very different.

Flood Rock will most likely be removed in the same manner as the rocks at Hallet's Point; but this operation will probably not be commenced until after the final explosion at the latter place.

Hallet's Point. The quantity of rock to be removed below mean low water mark is 50,584 cubic yards. The actual amount of rock to be broken up would, of course, be more.

Amount of excavation. The excavation must take in an area of 14,036 square yards.

Description of rock. The rock consists of hard gneiss, and is of exceedingly good quality, with the exception of a portion on the east side.

Stratification. The stratification is nearly vertical, and lies N. 5°, E. mag.

The work was first commenced in June, 1869.

Cofferdam. A cofferdam was erected between high and low water marks. It is built up in the usual manner with two rows of piles with puddle between, and is not strutted at all on the inside, as the excavation of the shaft commences close up to its inner wall. It is, however, tied by iron bolts to the rock on the outside, and its arched form also assists it in resisting the pressure of the water.

Shaft. Immediately within the cofferdam, the excavation of the shaft was commenced in Oct., 1869, and it was continued downwards until a depth of 33 feet below mean low water mark was attained. The dimensions of the shaft are shown in Pl. II.

Seams. The seams that were encountered in its progress were stopped up by means of oak wedges driven in wherever any signs of leakage were apparent.

Tunnels and transverse galleries. As soon as the shaft had been excavated to its full extent, the tunnels and transverse galleries were commenced to be driven with the intention of exploring the rock and opening the way to its final removal.

The tunnels are thirteen in number, and radiate outwards from the shaft. The tunnels to the right and left nearest to the shore line from the boundaries, show the extent of excavation in those directions. (Headings branch off from the tunnels.) The tunnel from the salient of the cofferdam and under the ridge of the reef, lies in the direction of the stratification of the rock, its length measuring the projection of the reef into the channel. The floors of the tunnels are as nearly as possible parallel to the surface of the rock.

The transverse galleries are concentric, and are eight in number on the east side, but only seven on the west.

Drainage. To accomplish the drainage of the works, two pumps are employed, each of the capacity of 1,000 gallons, with radial pipes penetrating into the extremities of the tunnels.

Only one bad case of leakage has occurred during the whole of the work. This case was caused by cutting into a seam. It was found necessary in this instance to put up a boarding, run cement in, and then build up a masonry wall. Oak wedges have been found sufficient in every other case.

The pumps have not yet been required to be worked up to their full capabilities.

Thickness of rocks that has been left.

The thickness that was first estimated to be left between the tunnels and the water was from 10 to 12 feet, but on account of the variable nature of the rock, it has been necessary to leave from 17 to 18 feet in some places, whilst in others, a thickness of 6 feet has been found to be sufficient. In one place, General Newton informs me, only 4 feet of rock remains to withstand the weight of the water, but this was due to an error in calculation on the part of the superintendent of the works. There is, however, no leakage at this point.

The piers will be very much more diminished in size and also in number before the explosions take place; this work will be quickly carried out, as a large number of men can be employed at one time. It will be a very delicate operation, as the amount of rock safe to remove can only be fixed by judgment. Great attention will have be paid to leakage, as this is the only means of discovering how much the rock will bear. Props will, of course, be ready at hand to strut up any part that shows any sign of failing.

Removal of debris.

For the removal of the debris of the rock after it has been broken up by the explosions, lines of rails have been laid down. These lines radiate from a turntable on the inner side of the shaft into the tunnels. Over the turntable is fixed a derrick which is worked by steam. The debris after it has been raised from the shaft is removed in trucks drawn by a small engine.

Boring.

The boring of the drill holes has been performed by the Burleigh boring machine, with some assistance from the Diamond drill and hand drilling.

Use of Diamond drill.

The Diamond drill was used at first and was found suitable for the work; but after the first 40 or 50 feet had been bored, the hardness of the rock seemed to be a great obstacle to its being used with advantage, the cost entailed being considerably more than where the Burleigh drill was used. The two Diamond drilling machines were, therefore, laid by, and the whole of the work for the last two years has been performed by the Burleigh drill.

Motive power.

The motive power of this machine is compressed air. Steam could not be employed for this work, as the large amount of condensation that must inevitably occur from the large surface of the pipes in contact with the cold air, no matter how carefully the pipes were packed, would render it inapplicable for such work. The discharge of the exhaust in the heading would also render working impossible. To meet this difficulty, the use of compressed air has been devised. It cannot, however, be said to be economical as a motive power, for the following reason. During the compression of the air a certain amount of heat is evolved. This heat tends to expand the particles of air, and the expansion thus produced works against the compression. During the passage through the pipes the heat that gave rise to the expansion is lost by contact with the colder surface of the pipes, and thus a certain amount of work that had been stored up is lost.

Use of compressed air for ventilation.

On the other hand, however, a great advantage is obtained by the use of compressed air by using it to ventilate the mines, and the gases caused by the explosions are readily removed by simply opening an escape valve.

Air chamber.

The air, before it is taken to the machines, is passed through an air chamber. This air chamber condenses any moisture which the air may contain. Without this precaution, the moisture contained in the air would be liable to freeze in cold weather, and form a coating of ice on the inside of the pipe. This crust, when a thaw set in, would break up from the interior and be forced down towards the end of the pipe, where it would form a considerable impediment to the passage of the air. This air chamber is, of course, kept at a lower temperature than the rest of the pipes. From this air chamber the air is carried to the boring machines by means of a large pipe about 8 inches in diameter, from which smaller ones radiate into the several tunnels.

The drills are mounted on carriages of which Fig. 4, Pl. III., is a representation. The drill point used is called the "tunnel drill." It drills 2½-in. holes, and feeds 30 to 36 inches without changing drill points. Extreme length, 5 ft. 7 in.

The work of boring into the rock in the side heading has been found easier than in the centre one. This is due to the stratification of the rock causing the part of the rock that has been bored to fall inwards. The boring in a heading is first commenced by drilling a hole 2½-in. in diameter in the centre of the heading, and having an inclination downward. A charge is then put in and exploded, carrying away the centre of the rock. The other holes are then drilled round and blown into it. The holes are from 3 to 4 feet in depth..

The Burleigh drills have made for the year 1873, an average for each machine of 28 feet per shift of eight hours. Their speed has steadily increased by experience gained, and for some months past may be reckoned at 30 ft. per shift.

Explosive used.

With the exception of a small quantity of gunpowder, nitro-glycerine has been used for all the blasting that has been carried out at Hallett's. No accident has yet occurred from its use. General Newton, U.S.E., in comparing this circumstance with the many premature explosions that have taken place in the works at the Hoosach Tunnel, attributes this immunity from accident to the use of the nitro-glycerine immediately after it has been made. For the Hell Gate excavations the nitro-glycerine is used only two or three days after it has passed through the last stage of manufacture, whilst that used at the Hoosach works has always been kept a considerable time. General Newton considers that the particles of water which are disseminated through the liquid in the process of purifying (and which render it milky in appearance) have not time to separate from it in two or three days, and that the existence of these particles through the mass contributes to a great extent to the safety of the material, and does not interfere with the explosive effect. Dynamite was tried once as an experiment, but the premature explosion of the charge, although caused by the extreme sensitiveness of the fuze, had such a bad effect upon the workmen that it has never since been employed. The charges are exploded by means of Bickford's fuze with a detonating cap at the

end of the fuze, of fulminate of mercury The nitro-glycerine breaks up the rock to a great extent into powder. For the Hallett's Point explosions charges of 8 to 10 ounces of nitro-glycerine are used in order not to disturb the roof of the tunnels. In preparing and firing at least 20,000 charges of nitro-glycerine there has been no accident.

Final explosion. For the final explosion 20 to 30 centres of explosion probably will be chosen. These centres will be connected with one another by means of troughs filled with nitro-glycerine. Nitro-glycerine will be the explosive solely used. Each centre will also be provided with fuzes which will be arranged so that all will be fired by electricity at the same moment. In case of any of the fuzes failing, the nitro-glycerine in the troughs will carry the flame.

Cost. The cost per cubic yard of excavation is about 35s.

Sunken Rocks below Hallett's Point.

Removal of rocks. It has been impossible to effect the removal of sunken rocks in the stream by tunnelling as the great traffic at this part of the river would cause so many collisions that any shaft or cofferdam, which might be placed in position for this purpose, would soon be destroyed. The work has therefore been carried out by vertical drilling, and this has been accomplished in the following manner.

Description of scow. A scow carrying the apparatus necessary for drilling is fitted up as shewn in Pl. III. This scow is 128 feet long, 56 feet beam, and about 8 feet in depth. It is very solidly constructed and is rather more than a foot thick throughout. Round the vessel is carried an overlap of 4 feet, and this seems to have afforded great protection in cases of collision. The overlap is faced with iron.

Well. In the centre is an octagonal well of 32 feet diameter, open throughout.

Dome. In this well is hung from four catheads at the corners of the octagon an iron dome. This dome is open at the top, and is constructed of curved girders on which are fixed iron plates. Its diameter is 30 feet. In this dome are placed the drills, seventeen in number.

Anchor legs. The anchor legs are used for the purpose of keeping the dome in an upright position. They are $4\frac{1}{2}$ inches square, with a drop of 48 inches clear. They slide in supports, and are fitted with cams to prevent them from sliding back. They can be let fall at the same moment by sliding round a horizontal ring a few inches. The ring is of iron, and supports the legs until they are required to be dropped.

Drilling engines. There are four engines to work the drill, one of which is represented in the plate. The pistons of these engines are four inches in diameter and have a stroke of 18 inches.

The engines for hoisting the dome are double oscillating, with worm and wheel 12 inches in diameter and 12 inches stroke. The capstans can either be worked by steam or hand.

The operation of drilling through the rock is performed in the following manner.

The scow is firmly moored over the rock to be broken up. This is done by towing her up into position and then securing her with two anchors from the bow and two from the stern. The number of anchors has often to be increased according to the position of the scow and strength of the current. As many as 69,000 lbs. of iron have at times been used to moor her. The dome is then lowered from the catheads until it touches the bottom. Immediately this takes place the lowering is stopped, and the iron ring that supports the legs is turned, and the anchor legs fall until they touch the ground, the cams preventing their return. The pressure of water on the surface of the dome caused by the super-incumbent weight prevents it from shifting. This is the reason the arched girders are plated over, as also to prevent drift-wood, &c., from getting within and interfering with the drilling apparatus. When this has been done an open platform is placed over the well and the drilling engines moved on to it. The plungers are then connected with the engines with ropes.

The drills used are simply iron-plungers of from 300 to 600 lbs. in weight, to the ends of which are attached drills of the form shown in Pl. III., Fig. 5, were the dimensions are shewn.

The use of spoons to scoop out the pounded rock have not been found to be necessary, as it was found that the upward stroke of the drill carried the stuff away.

Boring.

As soon as the drills have bored to a depth of from 10 to 13 feet, a diver is sent down, and the charges of nitro-glycerine lowered down to him. The charges of nitro-glycerine used are 50 lbs. They are exploded by the frictional machine. Seventeen charges are fired at the same time. It has been found impossible to calculate the effect of each charge, and, consequently, no records have been kept. The arrangement of bore-holes are shown on the plate, the dome being fitted with the same number of plungers for that purpose.

The following is from the Report upon Improvement of Rivers and Harbours :—

"The experiences derived from the operations of this machine are—

"1st. That the cylinder on the dome has never been of any use." (The cylinder referred to was one fitted in the opening of the dome. It was found perfectly useless, and, therefore, dispensed with. It is not shewn in the drawing, neither are the cranes which were used at first for raising or lowering the dome, and which have since been replaced by cat-heads. The cylinder and two of these cranes were swept off by the paddle of a steamer of 3,000 tons, which came into collision with the scow, the paddle-wheel cutting away everything on the side nearest to it, and nearly sinking the scow.)

"2nd. The dome has not acted as a dam, the top of the cylinder having never, except accidentally, risen to the surface of the water, while the bottom of the dome, not lying close to the rock, but levelled upon its legs, has permitted a free rush of the currents under it, and upon the person of the diver working upon the bottom. A rapid current, while the tide was running from the bottom through the dome, discharged itself through the top of the dome. The

water in the well-hole of the scow was always above the level of the exterior water, and in very rapid currents was on a level with the curbing of the well. The divers have reported that it was more difficult to work at the bottom with this machine than without its assistance; and the reason of this is manifest, viz., the obstruction to the currents arising from the broad bottom of the scow and from the dome, caused a thorough change in the velocities of the currents from the top to the bottom, decreasing the first by friction and by the velocity of the water pushing from behind, and the head raised by the obstruction mentioned (which tended to keep up the discharge) necessarily increasing the velocity at the bottom where the divers were at work. The result was that no work was done at the bottom by divers except during the time of slackened currents, when no protection was necessary.

"3rd. There has never been any practical difficulty in all currents to remove and to return the drills to the drill tubes from the deck of the scow, and consequently without the use of divers. This is very evident if recollection is had of simple mechanical devices which suggest themselves of lowering a drill to the mouth of the tube and inserting it, and likewise by reflecting that the drill tubes could be made of such a length as to reach nearly or quite to the surface of the water, and also could be made to slide in the collars supporting them, by which means the top of the drill tubes could be brought to any level desired for the insertion of the drill rods. All of these appliances were made.

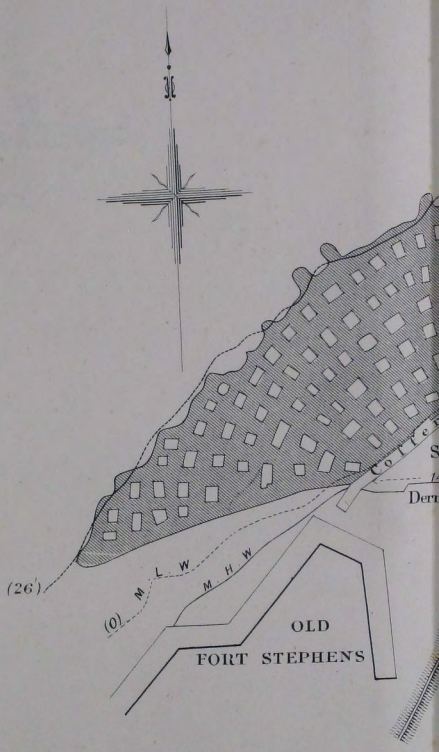
"4th. The only use of the dome for drilling purposes is to provide a fixed and stable platform, and with less weight than by other contrivances for a large number of drills operating at the same time.

"5th. That to make a dam of a dome or kindred shape, other and essential appliances which we never had occasion to use or construct are necessary."

The small stones which were found on the different rocks and which had to be removed before the drilling commenced, were taken up in buckets filled at slack water. Morris and Cuming's grappling machine was used for the removal of the larger pieces of rock.

G. B.

PLAN SHOWING EXCA



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PAPER IV.

SUBAQUEOUS BORING.

By Major F. HIME, R.E.

The following arrangements are suggested as a means of rendering boring operations independent of the rise and fall of the tide.

In Smooth Water.

Let us suppose that the greatest depth of water at high tide is 25 feet, and the rise and fall of the tide 15 feet.

The boring machinery is placed on a stage about 60 ft. by 30 ft., provided with 8 cylindrical legs 35 ft. long, capable of being raised and lowered by rack and pinion, and worm wheels worked by winch handles.

Below the stage is a decked barge, 66 ft. by 36 ft. by 4 ft. deep, provided with 8 cylindrical *masts* about 20 ft. high.

The legs of the stage pass through vertical tubes in the barge, and the masts of the barge pass through holes in the stage.

Thus when the stage is on its legs, the barge will float up or down on the legs; while the masts slide up or down through the stage.

To the top of each mast are attached two or more chains about 20 ft. long, by means of which the stage may be suspended from the masts at any period of the tide.

The foot of each mast fits into, and forms the piston of, a hydraulic cylinder about 4 ft. long, fixed in the barge, and worked by a force pump. The eight cylinders are connected by pipes to secure uniformity of action.

The mode of working the apparatus is as follows:—

The legs being drawn up and the chains adjusted so as to suspend the stage about 3 ft. above high water level, the apparatus is floated into position on the moorings, and the legs are let down to the bottom.

The chains from the mast heads are then cast off the hooks, leaving the stage standing on its legs.

Boring is now carried on through holes in the stage and corresponding holes in the barge, and the charges are placed ready for firing.

The chains are then attached to the stage as before, and the hydraulic pumps are set to work. The effect is first to press down the barge to its load-line in the water, and then to lift the stage bodily with its legs.

The fuzes are now lighted, and the whole apparatus being afloat, is hauled out of the way.

When the discharges have taken place, the apparatus is hauled into a second position on the moorings, and the stage is lowered to its original level by opening screw taps in connection with the cylinders, and allowing the water to escape.

The legs are again lowered to the bottom, the chains are cast off, and boring is resumed as before.

And so the operation may be repeated any number of times without reference to the state of the tide; for it will be seen that the stage, whether afloat or on its legs, is always nearly at its original level, just above high water line.

In leaving off work for the day, the stage should be left on its legs. Work may then be resumed in any condition of the tide.

The accompanying sketch (Pl. IV., Fig. 1) illustrates the principle of the system. It is, of course, only applicable to smooth water, like the system now in operation on the Tees; but it possesses the great advantage of being absolutely independent of the rise and fall of the tide.

Another way of securing the stage to the masts may be adopted instead of the chains and hooks.

Each mast to pass through a collar resting in bearings in a frame fixed to the stage, and capable of being clamped by screws as shown in Pl. IV., Fig. 2. The collar to be of steel, and to have teeth on the inside so as to grip the mast like a vice, and thus prevent the possibility of the stage slipping down.

This method would be more convenient than that previously proposed, and would be equally effective.

In Rough or Smooth Water.

The apparatus consists of a stage for the boring machinery (including motive power), a caisson, and a floating frame, as shewn in the sketches Pl. V., Figs. 3 and 4.

The stage is lowered and raised, that is, made to stand or float, by alternately filling and emptying the caisson. It is guided in its ascent and descent by means of the masts in the floating frame, and the extent of its upward motion is regulated by inserting pins in the masts at the required distance above the sliding rings.

The stage when aground stands on eight moveable legs. When afloat it rests on 24 hollow cylinders connecting it with the caisson, and through which boring is carried on. When the stage is on its legs the arms connecting it with the masts may be unshipped. This, however, will only be necessary in very rough or rolling water, as the floating frame has great stability.

The caisson is filled by opening valves from the stage. It is emptied by four pumps worked by steam. These pumps also supply the diamond crowns with water. In connection with the pumps there are air tubes to admit air to the caisson as the water is pumped out. The caisson will contain about 46,000 gallons. Four universal pumps, with steam cylinders 15 inches in diameter, and pump cylinders 12 inches in diameter, will empty it in 25 minutes, while the charges are being placed in position.

The advantages claimed for this system are as follows:—

1. It can be used in rough as well as smooth water.
2. It is independent of tides.
3. It does away with the tedious operation now practised on the Tees, of screwing together and unscrewing, lowering and lifting long lengths of 3-inch pipe. One short length of pipe let down through each cylinder is all that is required.

F. H.

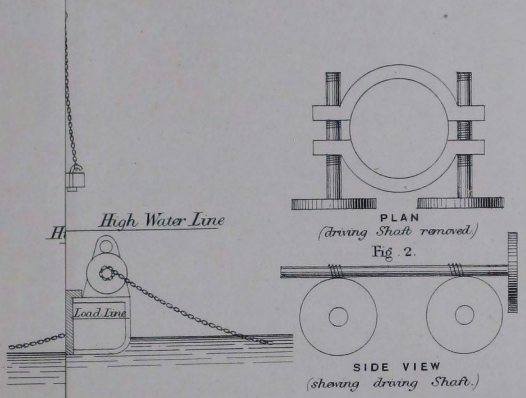


Fig. 2.

Low Water Line

THOS KELL, LITH. 40, KING STREET, COVENT GARDEN.

PAPER V.

ON THE RESISTANCE OF TIMBER TO CRUSHING.

By CAPTAIN T. FRASER, R.E.

In lecturing some years ago at the School of Military Engineering, Mr. Laslett, the Government Inspector of Timber, gave the results of some experiments on its crushing resistance, which he had carried out with pieces about 3 in. or 4 in. square. These results differed considerably from those usually quoted in such books as Rankine, &c.

Major Seddon, also, in Paper II. of Vol. XXII., of the Corps Papers, drew attention to a similar discrepancy between the results of a few of Mr. Kirkaldy's tests on whole timbers, and the usually received values for crushing resistance. With a view to check Mr. Laslett's results, and to use them, if confirmed, in the revision of the Bridging Part of "Instruction in Military Engineering;" permission was obtained to carry out ten experiments on a large scale, at Mr. Kirkaldy's testing-house. The nature and dimensions of the different specimens and the results are given in Table II. Except in the case of oak, these agree fairly with those from Mr. Laslett given in Table I.;* and the values for crushing resistance of timber, given in "Instruction in Military Engineering," have been revised accordingly.

The specimens were placed horizontally between two vertical faces of metal, one of which was made to approach the other till the wood failed.

It was intended to test seven of the ten specimens by direct crushing, but one of them, viz., the green larch, failed by buckling, though the ratio of its length to its diameter was less than 6 : 1. It is true the ends were not fixed, but as they were turned square, buckling would not, under ordinary circumstances, have occurred, unless the length had been somewhat more than 11 times the diameter, which is said to be the ratio for buckling with rounded ends.

This seems to show that in using green timber, in the field, for instance, we must calculate on buckling taking place with lengths about twice as short in proportion to the least diameter, as with dry timber. In spite, however, of its failure in this way, it will be noticed that this specimen had a higher resistance than dry fir.

* Mr. Laslett has since published his book on Timber, in which the mean values of corresponding experiments are in every case higher than those of his given in Table I., with the exception of English oak; for which the value given is about 5,800.

Long columns.

Formulæ for the failure of long columns under compression are given by Rankine and Reuleux;* that by the latter, when both ends are rounded, is

$$W = \frac{\pi^2 \, E \, I}{l^2}$$

Where W is the breaking weight in lbs.: E the modulus of elasticity; I the moment of inertia (in which d is the least dimension at the dangerous section);† l the length in inches.

In order to test the value of these formulæ, two long columns, viz., Nos. 1282 and 1281, were crushed. To prevent the weight of the beams from initiating bending, the ends were rounded in the way shown at the foot of the Table. This, as was expected, hindered the tendency to bend downwards, while it left the beams free to buckle laterally, in which direction each of them failed. The Riga beam was placed with the larger dimension vertical.

Applying Reuleux's formula to these examples, we find that for the spruce, E = 1,799,000 nearly, or say 1,800,000; while for the fir, E = 864,270; the latter is lower than the values usually received. ‡

The direct crushing resistances obtained from other portions of the same spruce and fir logs are respectively 4217 and 2365, which are somewhat in the ratios of the above values for E.

Hence, although, no doubt, the tensile strength of timber also affects the question of failure by buckling, these experiments, as far as they go, point to the fact that the resistances to direct crushing will give an approximation to the values for E for the same woods.

It is unsafe, of course, to generalize from such small data as these few experiments afford; but it is worthy of notice that the spruce pole No. 1,282 was tested, on a large scale, for cross breaking, and the value for f in the formula

$$\frac{W \, l}{4} = \frac{f \, I}{y_o}$$

was found by Lieutenant Jennings, R.E., to be 10,800.

The value for f for Riga fir of similar quality, when tested on a large scale, was found by Lieutenant H. R. Sankey to be about 5,000; and $\frac{10800}{5000}$ is approximately $= \frac{1799000}{864270}$ or $\frac{f}{f_1} = \frac{E}{E_1}$.

This relation does not seem improbable, as failure by cross-breaking occurs by the crushing of the upper fibres.

Although special machinery is required for crushing experiments, the cross-breaking resistance can be tested anywhere; and, if the above relation were

* In "Der Constructeur."

† See further explanations in Part III., Par. 362 (Bridging), "Instruction in Military Engineering," where, however, π^2 should be substituted for 15·5 in the formula for crushing.

‡ Laslett, in his book on timber, gives 752,420 as the value for E for Riga fir; while Rankine gives the value as 1,460,000 to 1,900,000, and about 14,000,000 for spruce. Reuleux's mean value for E for building timber is 1,564,420 with British inches and lbs.

established by further experiments, we should have a ready means of arriving, approximately, at the values for E, for local timbers in any part of the world.

Bearing in mind that the low value for E in experiment 1281 was probably due in part to the fact that the timber was squared: as a rough rule for the field, we may, it is thought, take the mean value for E to be 1,013,200 for dry timbers; and should use rather a larger factor of safety with squared than with round timber.

Then for dry timber, the formula becomes

$$W = \pi^2 \times 1{,}013{,}200 \times \frac{I}{l^2} = 10{,}000{,}000 \frac{I}{l^2}$$

If we apply Gordon's formula as given by Rankine, viz.:—

$$f = \frac{P}{s}\left(1 + 4a \times \frac{l^2}{h^2}\right)$$

to experiments 1,281 and 1,282, we have for 1,281

$f = 7{,}200$; $a = \frac{1}{250}$; l in. $= 112$ in.; $h = 4{\cdot}18$ in.; $s = 21{\cdot}06$ in.

$$\therefore 7{,}200 = \frac{P}{21{\cdot}06}\left(1 + \frac{4}{250} \times \frac{112^2}{(4{\cdot}18)^2}\right)$$

$\therefore$ P, or the B.W., $= 12{,}147$ lbs.; the actual B.W. being 20,859.

For the spruce (No. 1,282) where $s = 28{\cdot}5$; $l = 198$ in.; $h = 6{\cdot}05$ in., we find that P., or the B.W., should equal 11,412, supposing the formula to apply to round timber, while the actual B.W. was 29,785.

In either case the error is larger than it would be, even using the approximate formula

$$W = 10{,}000{,}000 \frac{I}{l^2}$$

General results.

We can not, of course, draw conclusive results from so few experiments as were made on this occasion, but as far as they go, the following seem to be the results:—

1st. There is reason to suspect that the resistance to direct crushing has generally been over-rated: we were therefore justified in revising our bridging tables.

2nd. The values for the modulus of elasticity for wood, as generally accepted, appear too high, and require revision.

3rd. Buckling may take place in green timber, with a ratio of length to diameter only one-half that with dry timber.

4th. The values for E appear, from these experiments, to be somewhat in the ratios of the direct crushing resistances; and also in the ratios of the cross-breaking resistances.

5th. From the high values got from the round specimens, it seems that timber as it grows in the round, is somewhat stronger than when the outer fibres are cut in squaring it.*

* In experiments 1274 and 1282 the timber was in the natural state; in No. 1275 a round log was turned down to 6·18 in. diameter.

6th. Using the corrected values for E, Reuleux's formula seems the most accurate, and even the rough rule,

$$W = 10{,}000{,}000 \frac{I}{l^2}$$

promises fair results.

7th. The result of the single test for tensile strength does not vary much from the generally received value; because, no doubt, the scale of the experiments, affects the result least in this case.

In conclusion, it is evidently desirable to carry out further and systematic experiments in these subjects, with the admirable machinery which, thanks to Mr. Kirkaldy, this country alone possesses.

T. F.

TABLE I.

Table of the resistance of Timber to a Direct Crushing Stress, as given for a Square Inch of Section, by different authorities. The remarks refer to the quality of the specimens tested by Kirkaldy.

Name of Wood.	From Rankine's Useful Rules.	From Laslett.	From Kirkaldy. (Table II).	Remarks.
Fir (Riga)	5,750	4,051	2,430	Indifferent
Oak (English) ..	10,000	7,571	3,946	Very good
Pine (Canada Red)	5,375	2,705	3,203	Fair
Pine (Kawrie) ..	..	4,546	5,269	Excellent
Spruce	..	3,934	4,217	Do.

TABLE II.

Results of Experiments to ascertain the Resistance to Depression and Rupture, under a gradually increased Thrusting Stress, of Nine Specimens of Wood, as per margin.

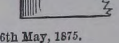
Test No.	Description.	Dimensions. Size.	Area.	Length.	Per square inch. Stress in pounds. Depressions, inch. 1,000	1,200	1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,800	3,000	3,200	3,400	3,600	3,800	4,000	4,200	4,400	4,600	4,800	5,000	5,200	5,400	Ultimate stress. Total.	pr.sq.in.
J		inches.	sq.ins.	ins.																								lbs.	lbs.
1280	Kawrie pine	6·00 by 4·00	24·00	36	·021	·027	·031	·035	·040	·045	·050	·054	·058	·062	·066	·070	·074	·078	·082	·086	·090	·095	·100	·105	·111	·122	..	126,456	5,269
1279	English oak	6·00 by 6·00	36·00	36	·022	·032	·040	·049	·058	·062	·070	·080	·088	·096	·104	·112	·128	·148	·194	...	...	...	...	...	...	..	...	142,080	3,946
1278	Canadian red pine	6·00 by 6·00	36·00	36	·022	·031	·038	·043	·050	·056	·060	·066	·072	·082	·095	·120	...	..	...	...	...	..	...	...	..	..	..	115,299	3,203
1277	Riga fir	5·95 by 5·90	35·10	36	·046	·060	·072	·086	100	·120	·142	·164	...	...	...	...	...	...	...	..	..	..	...	...	...	...	..	87,728	†2,499
1276	Riga fir	5·05 by 4·00	20·20	24	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...	...	...	...	..	...	...	47,790	†2,365
1274	Spruce pole..	6·75	35·78	12	..	...	...	..	...	..	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...	...	150,880	4,217
1275	Larch, green	6·18	30·00	36	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...	...	78,410	2,614

					300	400	500	600	700	800	900	1,000		
1282	Spruce pole...	6·05	28·50	*198	·080	·108	·135	·164	·193	·230	·272	..	29,785	1,045
1281	Riga fir	4·18 by 5·04	21·06	*112	·092	·130	·182	·245	·303	·397	·460	..	20,859	990

Tensile strength of spruce pole, J 1283 = 9073 lbs. per square inch.
Nos. 1274, 1282, and 1283 were the same pole.
Nos. 1281 and 1276 „ „ baulk.
† Different specimens.

Both ends of the seven specimens were faced in the lathe.
Short columns of Green-hart = 10,280 lbs. crushing resistance per square inch.
* Both ends of the two specimens were rounded thus

Plan



DAVID KIRKALDY,

99, Southwark Street, London, S.E., 26th May, 1875.

PAPER VI.

ON THE FAILURE AND REPLACING OF THE PIERS OF A VERANDAH AT MALTA.

By Mr. HENRY WILLIAMS, Surveyor.

The removal and replacing of the lower piers of the verandah of a three story building, for the purpose of substituting a harder material, having been successfully accomplished at Malta, I deem it my duty to give a short description of the course adopted, hoping that the experience thus gained may be found useful to others.

The married soldiers' quarters at Floriana Barracks, Malta, which was the building operated on, were approximately estimated for as a two story building, but the exigencies of site required that they should be three storied. No evil results were, however, anticipated, as numerous other three storied buildings built of the same material by the War Department, and of no greater section on the ground floor, had stood very well.

The site was unfavourable from two causes: first, it was at the lower part of the Floriana parade with high ramparts on its other side, and, consequently, subject to perfect inundation from every shower of rain; secondly, it was made-ground to the depth of about 20 feet, and the site of an old cemetery. As might be expected from both these causes, difficulties were experienced from the very commencement of the building operations, and it was only by the care bestowed on the work that it was carried on to completion.

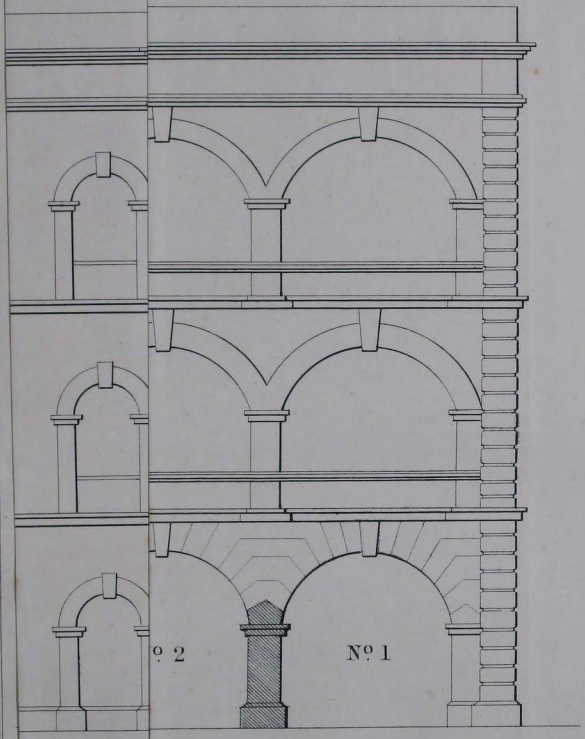
On the night of the 28th October, 1874, the piers in the lower-floor verandah showed signs of giving way, and the centering was at once replaced and the building shored up. The failure was undoubtedly caused by the foundation being on made ground of unequal depth, which having been thoroughly saturated by a heavy rain-storm on the 26th idem, allowed the building to settle unequally, thus pulling the pier (No. 1) see Pl. VI, which failed most, slightly over and crushing one side, the other piers showing signs of failure, either from the greater weight thus brought upon them, or from unequal beds in the dressing of the stones.

A carefully conducted series of experiments to determine the resistance to crushing of the Malta soft stone, demonstrated that only in exceptional cases, can a resistance of 10 cwt. on the square inch be obtained.

The load on these piers is 50 tons, their section is 3 square feet, or the load is $\frac{1000}{432} = 2{\cdot}3$ cwt. per square inch, which gives a factor of safety of about 4. With bad foundations—stone of variable quality, perishable and weak—and an unequal settlement increasing the pressure on one side of the pier and relieving it on the other; this factor, which would have been enough in building with rock foundations, proved insufficient in this. To rebuild the piers in soft stone

MALTA

MARRIED Q



Centering was fixed at Nos 1 and 2 arches Figure 1, as well as the Strut and Needle shewn in Figure 2 At Nos 3, 4 and 5 Arches, the openings were built up solid.

THOS KELL. LITH. 40, KING STREET, COVENT GARDEN.

would have been to court another failure, and the Commanding Royal Engineer obtained authority to substitute hard stone.

To relieve the four piers supporting a superincumbent mass of masonry weighing approximately 200 tons, with heavy mitred cornices and ashlar worked face, without disturbing any part of the building, or the symmetry of the facade, required some consideration.

The first pier was already partly relieved of its weight by the centres and struts, and it was determined to let these remain. To complete the support, the spandril of the verandah arches, just above the springing, was cut through and a needle beam, 15 in. by 12 in. inserted (see Fig. 2), which was secured to the main building, and supported on uprights firmly planted upon hard wood sole pieces. The uprights were so cut and fixed that they inclined slightly to the building, thus causing them to act as struts as well as supports. They were cut 2 in. short of their height, to admit of wedges being driven. To take the weight from the pier, two sets of hard wood fox-tail wedges, payed over with soft soap, were carefully and slowly driven between the uprights and the needle beam, until the supports gave out a ringing sound when tapped with a hammer, caused by the weight they were supporting.

The openings between the other three piers were not encumbered with centres, and a simpler method of relieving the piers could, consequently, be adopted. The openings were, therefore, built up with solid masonry set in Puzzolana mortar, a baulk of timber the length of the opening being used as a foundation, and great care being taken in fitting the stones to the curves of the existing arches. To further ensure the weight being taken by the new work, wedges of stone and hard wood were driven into the vertical joints, thus causing the stones meeting the curve of the spandrils to jam tightly.

There being doubt as to the front of the verandah, 50 feet in height, keeping its vertical position when the piers were removed, a strut 36 feet long, 15 in. by 12 in. section, was fixed over the first pier, that being the least secure. The strut was supported at the bottom by a truss firmly fixed in the ground, and at the top was halved and spiked to a fir plank planted against the face of the building.

Over each pier on the roof, the walls were secured in their vertical position by wrought iron tie-rods, 1 in. diameter, passing transversely through the building and exterior walls, connected to horizontal timbers running the length of the fronts, prepared with a reversed screw in the centre for drawing the rods and timbers tight to the walls.

In order to test whether or not the new supports had taken the weight of the building from off each pier, a saw-cut was made in the mortar joint of the springing stone just below the supports. The mortar from the joint was then cleared away, and a space of $\frac{3}{8}$ths of an inch remained between the top of the pier and the springing stone. The soft stone piers were then removed, and replaced by hard stone set in Portland cement.

The hard stone being prepared, the removal and replacing of each pier took about four hours. Soon after completion, the supports were removed, and the whole finished without a mortar-joint anywhere on the front being broken.

H. W.

PAPER VII.

ON A DIAPHANOMETER.

By CAPTAIN ABNEY, R.E.

Having recently had occasion to consider the means of measuring the illuminating power of light, it occurred to me that a simpler plan than either Bunsen's or Rumford's might be practicable. If light be thrown on a diaphanous screen and be viewed through a slit by a telescope, the apparent brightness may be reduced by causing a black glass wedge (corrected for refraction by a similar white glass wedge cemented to it) to pass between the light and the telescope, the reduction taking place according to the following law. If B_o be the original brightness of the light, μ the co-efficient of absorption, x the thickness of the wedge in the units for which μ is calculated, and if B_1 be the reduced brightness, then

$$B_1 = B_o \epsilon^{-\mu x}$$

a formula which can be readily found from the laws of absorption.

If, then, by some means, a feebler standard light can be sent through the bottom half of the same slit, the bright light shining through the top half can be reduced till they both show the same apparent brightness.

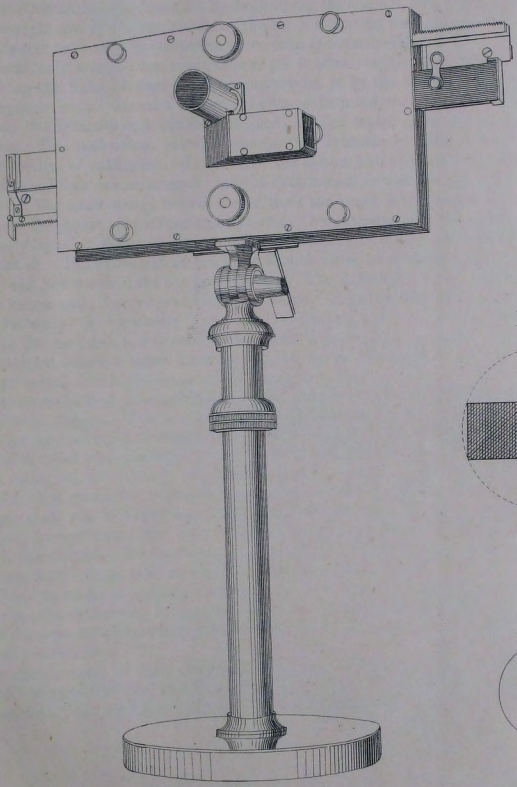
The accompanying figures show the method by which this is effected: through the top half the light to be measured is sent, whilst through the bottom half the comparison light is reflected by a prism of total reflection.

In practice, two wedges are used, one for the bottom half and one for the top half of the slit, the comparison light often being inconveniently bright is reduced in brightness till it appears of an easily comparable character. The top wedge is now moved along the top half of the slip till the same intensity is given, the thicknesses of the parts of the wedges used are then noted,* and the relative brightnesses of the two calculated from the above formula. It was found inconvenient, however, to have to judge of the relative brightness by lines of light placed one below the other. It was evident that if one line could be placed immediately alongside the other in a dark field, the power of comparison could be largely increased. Certain mechanical difficulties caused me to abandon the idea of effecting this in the instrument itself, so I resorted to an artifice in the telescope with which the lights were viewed. The object glass was cut down

* Measured by the length of the wedge from the zero point.

DIAPHANOMETER.

Front View.



Back View.

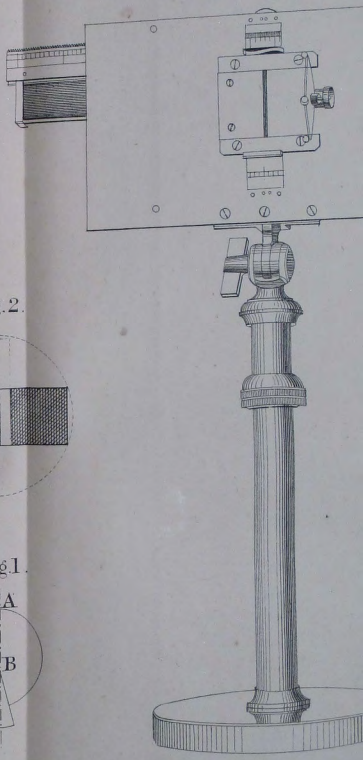


Fig. 2.

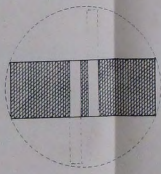
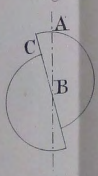


Fig. 1.



the centre and separated, as shewn in Pl. VII., Fig. 1, the line of the two halves forming an angle with the vertical, which could be varied at pleasure. When the whole slit was viewed with such an object glass in the telescope, two images were formed alongside one another, but the top of one appeared at the same level as the centre of the other, as in Fig. 2. Thus, the image of the bottom and the top of the slit appeared in the same field, and could be brought as close to one another as thought desirable, by diminishing the angle A B C, Fig. 1. The relative brightness of the two halves of the slit can now be well judged, and, I believe, never need vary in estimation more than one-hundredth.

Hitherto, only mention has been made of the *brightness* of the light, measured by viewing the light *through* a diaphanous screen, or by the illumination of a white opaque body. It must, however, be borne in mind that brightness depends on the *intensity* and *quantity* of light, a point which generally escapes attention. This instrument can also measure the intensity of light by what I call the method of extinction. In this case the bottom half of the slit is closed, and the naked light whose intensity is to be determined, viewed through the slit as before. The black wedge is then moved until the point is attained at which the image disappears, and its position is noted. By extinguishing the standard "intensity light" in the same manner, a direct comparison of relative intensities is arrived at. The extinction of the light should never be considered complete till the eye has watched the slit two minutes. The determination of intensity by this means will, it appears to me, be of value. It has usually been assumed that "intensity" $\times$ "quantity" $=$ "the illuminating power." This I believe not to be the case, as a few determinations I have made point to a more complicated relation between these three factors, owing to the lower wave lengths being converted into higher ones as the intensity increases.

I have manufactured photographically plain glass to take the place of the carefully ground wedges. This is accomplished by allowing light to pass through the wedge, and taking an ordinary photographic negative of it. The image thus obtained is toned with platinum, all the silver and its chloride dissolved away in proper menstrua, and nothing left but the black deposit in the collodion film. The glass thus graduated is placed in a muffle, and the image burnt in. The resulting glass will be found beautifully graduated in black tones, and be comparatively inexpensive. The most arduous work in connection with the instrument is the obtaining the co-efficient μ; with my first wedge it took me two months to find, though now an hour is sufficient to graduate a new one. I find that when the wedge is perfectly black in colour—*i.e*, having no tinge of green or blue in it—the easiest plan is to expose sensitive chloride of silver paper beneath it, and compare the tints obtained from it with those from one whose co-efficient is already determined.

The measurement of light through absorptive media has not been much studied, owing to the want of a good instrument. I am in hopes from opinions expressed, that the diaphanometer may fill a gap hitherto partially void.

W. De W. A.

PAPER VIII.

NARRATIVE OF THE OPERATIONS OF THE BRITISH NORTH AMERICAN BOUNDARY COMMISSION, 1872-76.

By Capt. FEATHERSTONHAUGH, R.E.

The boundary between the British possessions and those of the United States on the Continent of North America had, previous to the appointment of this Commission, been marked from the Atlantic Ocean, westward, to the north-west angle of the Lake of the Woods, and from the Pacific Ocean, eastward, to the summit of the Rocky Mountains.

In the interior of the continent between these terminal points, the boundary was unmarked, though determined, geographically, by the Convention of the 20th October, 1818. This portion of the country comprised between the meridians of 95° 14′, and 114° west longitude, was, to a great extent, unknown, but was believed to be all prairie land or bare plain, with the exception of the swampy districts between the Lake of the Woods and the Red River of the North. West of the 100th meridian the great American desert, alluded to in most of the books of travellers in these regions, was supposed to lie; further on the "bad lands" of the Missouri were said to be crossed by the line, and further on again were the hunting grounds of the Blackfoot and Blood Indians, who were reported to be unfavourably disposed to intruders. All these obstacles turned out, as will be seen in the course of this narrative, to be overrated. The great American Desert was certainly deserted; but grass, water, and, at one time of the year, buffalo abounded in it; the "bad lands" were small in extent, and the Indians were friendly.

The north-west angle of the Lake of the Woods had been identified and marked by Commissioners from both nations in the year 1826, and from this point, according to the Convention, the boundary was to run due south as far as the 49th parallel of north latitude, and then along the said parallel to the Pacific Ocean. The portion between the Pacific Ocean and the summit of the Rocky Mountains having been marked in 1858-62, the work of the present commission came to an end when the latter were reached.

The staff of the British Commission were the following :—

H.M. Commissioner, Major Cameron, R.A.
Secretary, an officer of the Royal Engineers.
Chief Astronomer, Two Astronomers } Officers of the R.E.
Two Surveyors.
One Surgeon.
One Geologist and Naturalist.
One Commissariat Officer.
One Veterinary Surgeon.
Four Sub-Assistant Astronomers.
Three Assistants to the Surveyors.
One Assistant Surgeon.

The last fourteen of these offices were filled by Canadian gentlemen, who were nominated by the Government of the Dominion. There were also in the permanent employment of the commission 44 non-commissioned officers and men of the Royal Engineers, one waggon-master, 12 depôt keepers, (who were persons qualified to undertake the care of provisions and to issue stores and rations), and 13 officers' servants.

During the period of work in the field, teamsters, axemen, and labourers were hired for the season at so much a day. The number of these in each year are shewn in the tables at the end of the appendix. The detail of the trades of the non-commissioned officers and men of the Royal Engineers, and lists of the instruments and stores brought from England for the use of the commission are given in the same place.

DEPARTURE FROM ENGLAND, 1872.

The Commissioner and the Secretary left England in July, 1872, and proceeded to Washington, U.S. From thence they went to Ottawa, the capital of the Dominion of Canada, and finally started for Red River in the beginning of September.

The officers and men of the Royal Engineers, having with them all the instruments and outfit which had been purchased in England, left Liverpool on the 22nd August, 1872, Captain Anderson, R.E., the chief astronomer, being in command of the party, and they reached Quebec at the end of the month. Hence they proceeded by water to Toronto, on Lake Ontario, thence by railway to Collingwood, on the Georgian Bay, where they embarked in one of the Lake Superior line of steamers, which took them to Duluth, in the State of Winconsin, U.S. The destination of the party for this port had been reported by Captain Anderson to the Major-General commanding the United States troops in the district; and, on arrival, a telegram was received from the Adjutant-General of the division giving the requisite authority to pass through the country, and offering, with great consideration, that an officer of the staff should accompany the party to the frontier. As no peculiar difficulties were anticipated, it was not thought necessary to accept this kind offer, as the doing so would have entailed a long journey upon the officer concerned.

Leaving Duluth by the railway, the party travelled for 30 miles up the gorge of the St. Louis river, the scenery of which is remarkably bold and picturesque, the stream following a number of precipitous descents, broken by large pools of still, clear water, around which immense slabs of rock lie tossed in every conceivable position. The railway runs along the north side of the gorge, and crosses the numerous lateral ravines, which open into it, on high trestle bridges, mostly built on a curve plan, and so arranged that the traveller, looking out of the carriage windows, sees no roadway beneath him but only the rocks, perhaps 100 feet below. Although the delicate but strong construction of these bridges was admired, yet a feeling of relief was experienced when they had been all passed. Emerging on to the level country at the top of this gorge, the North Pacific Railway carried the party due west, to its intersection with the Red River of the north, a distance of 350 miles, the first 150 being through woods and swamps, after which the open prairie was reached.

The first aspect of scenery over country similar to which the party were destined to work for so many miles, could not fail to be interesting, and even impressive; but, as a mere landscape, the prairie, as seen from a small elevation, has few elements of beauty. The spectator appears to be in the middle of a small circle, just as is the case at sea, and the feeling which is induced is that of an oppressive monotony. After about 18 hours travel by rail, the detachment reached Moorhead on the Red River, where they overtook the Commissioner and the Secretary. Arrangements were here made for the transport of the baggage and stores, &c., by carts, along the coach road northwards, and the party commenced their march in the same direction. The road follows the general course of the Red River, running from point to point of the numerous bends of that stream, and on the evening of the third day, the head of the navigation at that season was reached at a place called Frog Point, above which, during most of the year, the water is too shallow for steamers. The men, baggage, and stores were all embarked here, on the "Dakota," one of the Kitson Red River line of steamers. These vessels, on account of the shallowness of the stream and its numerous bends, are of peculiar construction. The hull is very shallow, drawing only about three feet of water, and they have a single paddle wheel placed at the stern. When one of these steamers takes barges or freight boats with her, they are lashed to her sides, or even placed in front of her bows, it being impossible to take them in tow on account of the paddle wheel. In ascending the river when a sharp turn has to be passed, it is usual to run the steamer sideways against the bank in the angle of the bend, get her head round, and start again in the new direction.

After two days steaming the commission arrived at the frontier on the 20th of September, and went under canvass on the prairie on the north side of the line; the United States commission were camped a short distance off, having arrived about ten days before. The Canadian officers and other members of the British commission had also arrived by the "Dakota," or by the previous steamer, and the entire staff was now ready to commence work.

At this time there were only three or four buildings on or near the 49th

parallel, where it strikes the Red River. One of these was the Canadian Custom House, another was the Hudson Bay Post, which was surrounded with a palisade; the others were mere huts, inhabited by Half-breeds. The exact position of the boundary was not known; by some persons it was supposed to be three-quarters of a mile north of all these buildings, though the general opinion placed it very much where it was eventually found to be. Major Twining, of the United States Engineers, was already engaged in observations for latitude with the zenith telescope; and the British astronomers commenced to do the same on a meridian conveniently near to that of the American observatory tent.

The group of buildings mentioned above was at that time called North Pembina, the village of Pembina being two miles further south, where the river of the same name flows into Red River. The United States custom house is in this village, and Fort Pembina, which contains a garrison of three companies of United States infantry, is one and a half miles further south again, on the west bank of Red River.

The British and United States Commissioners having agreed upon a plan of operations for the autumn, the British Commission was divided into the following working parties:—

3 Astronomical parties; 3 Surveying parties; Staff.

The astronomical parties were in charge of Captain Anderson, Captain Featherstonhaugh, and Lieut. Galwey, R.E.; and the surveying parties were under Colonel Forrest, of the Canadian Militia, P.L.S.,* Mr. A. L. Russell, P.L.S.,* and Sergeant Kay, R.E., respectively.

Each astronomical party was equipped with a zenith telescope, a portable transit instrument, a sextant, two sidereal and one meantime chronometers, a 7-inch transit theodolite, chain and arrows, &c. Each surveying party had a 5-inch transit theodolite, three prismatic compasses, chain and arrows, sketching cases, and mathematical instruments sufficient for plotting the traversing.

While the various parties were preparing for the field, a snowstorm of great violence commenced on the day following the equinox, and continued for 48 hours. It had been preceded by the passage of large flocks of wild geese to the south, which went screaming over the camps, being generally at a great elevation. This storm, though sufficiently unpleasant, was taken by the local people as a presage of a late winter, and this proved to be the case.

The following plan of operations for the autumn and winter was agreed upon between the Commissioners. The position of the north-west angle of the Lake of the Woods, as marked in 1826, was to be identified, and the necessary surveys of the shore were to be made; the meridian line from here southwards to the 49th parallel was to be traced and marked; the intersection of the western shore of the Lake of the Woods by the said parallel was to be determined by joint astronomical observations; and as many intermediate points as possible between the Lake and the Red River were to be established, taking into consideration the nature of the country and the lateness of the season. The joint determina-

* Provincial Land Surveyor.

tion of the boundary at North Pembina was also to be finished, and the surveys on each side of the line were to be pushed forward in an easterly direction.

The article of the Convention of the 20th October, 1818, under which the Boundary Commissions were constituted, is as follows:—

ARTICLE II.

"It is agreed that a line drawn from the most north-western point of the Lake of the Woods along the 49th parallel of north latitude—or, if the said point shall not be in the 49th parallel of north latitude, then, that a line drawn from the said point due north or south, as the case may be, until the said line shall intersect the said parallel of north latitude, and from the point of such intersection due west along and with the said parallel—shall be the line of demarcation between the territories of His Britannic Majesty and those of the United States, and that the said line shall form the southern boundary of the said territories of His Britannic Majesty; and the northern boundary of the territories of the United States from the Lake of the Woods to the Stony Mountains."

The north-west angle of the Lake of the Woods being considerably to the north of the 49th parallel, a meridian line had to be traced southwards.

In the beginning of October, the main bodies of both commissions started for the north-west angle of the Lake of the Woods, leaving one of the British astronomical parties at North Pembina to finish the observations for latitude; the surveyors on each side had also commenced working in an easterly direction along the 49th parallel. On arriving at the north-west angle, Major Twining and Lieut. Galwey proceeded in boats across the Lake of the Woods to Buffalo Point, where joint observations were commenced for latitude. The commissioners and the two chief astronomers pitched camp at the north-west angle, and a search was commenced for the reference monument erected by the international commissioners appointed under the 7th Article of the Treaty of Ghent. "The most north-western point of the Lake of the Woods," mentioned in the 2nd Article of the Convention of 1818 (quoted above) was agreed and declared by these commissioners to be at a specified distance measured in a given direction from this monument. At the same time the latitude and longitude of the said "north-west point" were given. It was evident that the first method of identifying the "north-west point" was far the most accurate, provided the reference monument could be found. The range of the possible position of the north-west point, in longitude, was fortunately limited by the width of the bay, which was not more than 100 yards, its sides running north and south. Observations for latitude were therefore taken with the sextant, and the position of the reference monument was in this way found within the limits of the error of the sextant observations, and of the width of the bay, supposing that the observations taken at the time when the reference monument was constructed were correct. The probable error of the latter observations was, however, unknown; nor was there any information at that time as to what instrument had been used in taking them. The search for the reference monument occupied three days, at the end of which time some Indians appeared, who said they could point out its site. They accordingly indicated a spot which was covered with

water about 18 inches in depth, and here the remains of a square crib of logs were found. This was assumed to be the reference monument, and the position of the north-west point was determined by laying off the six measured courses leading thereto, as specified in the Treaty of Ghent.

Observations for latitude were then taken with the zenith telescope by Capt. Anderson, R.E., by which the latitude of the north-west point, found as described in the preceding paragraph, was determined to be 3·7 seconds greater than it was stated to be by Dr. Tiarks, the astronomer to the commission under the Treaty of Ghent.

It was afterwards ascertained that Dr. Tiarks had used a sextant, and that his observations had been taken, not with a view of determining the absolute position in latitude and longitude of the spot in question, but only its position relatively to another point, which appeared to have equal claims to be considered the north-west angle of the lake. The discrepancy, however, is very small, and the position of the north-west point, as determined from the spot where the remains of the crib of logs was found, was finally agreed to by the Commissioners of both nations. The work was proceeded with at the time on the supposition that such would be the agreement on the subject, and a meridian line was laid off by the astronomers of both commissions, passing through the north-west point.

About the beginning of November, the two astronomical parties at Buffalo Point had completed their observations, and were back at the north-west angle. The United States commission then withdrew from the field, and retired to winter quarters at Detroit on Lake Erie. Lieut. Galwey and his party returned to North Pembina by the same way that they had come, and proceeded along the 49th parallel about 20 miles eastward, to a well marked ridge, which runs from south to north, being the edge of the Red River valley, and also the eastern limit of the prairies. Lieut. Green, of the United States Engineers, had traced an easterly line, tangent to the 49th parallel at Red River, as far as this, and for about 14 miles beyond it to a place called Pointe d'Orme, where the boundary strikes the Roseau River. Lieut. Galwey established an astronomical station on the ridge, and commenced observing about the middle of November; having determined the latitude, and erected a substantial mark, he returned to North Pembina.

During the time that Captain Anderson was observing for latitude at the north-west point of the Lake of the Woods, his party were engaged in cutting through the woods in order to prolong the meridian line southwards. There were a number of Chippewa Indians camped at the angle, and twelve of the strongest looking were hired as axemen. Many days passed, however, before they could be got to understand that the work had to be done regularly, and continued for so many hours a day. They would commence in the morning sometimes with great vigour, but would soon stop, light a fire, and sit round it smoking; then when, after much trouble, the non-commissioned officer or sapper in charge had got them to work again, they would suddenly break off and proceed gravely to Captain Anderson's tent, perhaps some two or three

miles off, where they would ask for more pay or more food. After a fortnight, only half-a-dozen of these men were able to continue at work, the others breaking down through want of stamina. They were all miserably clad, and the working in the icy water of the still unfrozen swamps was very severe upon them; they were, however, useful in carrying loads when the camp was shifted southwards along the line, or when supplies were being brought up. About three weeks after the cutting had been commenced, the frost set in, and greatly improved matters by giving a hard and dry footing, the timber became less thick and of smaller size, and three white men having been engaged as axemen, the work progressed more quickly. As the Lake of the Woods was approached, the woods merged gradually into small half dead tamaracs, which were replaced in the immediate vicinity of the shore by willow bushes. The length of this cutting was 16 miles and 397 feet, the ground passed over was all swampy, with the exception of a ridge of red granite (in situ) 6 miles south of the N.W. Point. The timber was birch, cedar, and tamarac.

On the 21st November the cutting was finished, and marks having been left by which the permanent iron monuments might be erected as soon as they could be provided, Captain Anderson withdrew his party and returned to North Pembina. Here observations for longitude were commenced, the local time being compared by means of the electric telegraph with that of Chicago in the State of Illinois, U.S. The local time at North Pembina was obtained with a portable transit, Lieut. Galwey taking the observations; while the electric signals for comparing the chronometer with that at Chicago were sent by Captain Anderson. Mr. Lindsay Russell, Deputy Surveyor General of the Dominion of Canada, undertook the necessary work at the Chicago end of the wire. The weather was unfavourable, being cloudy and very cold; but the result was satisfactory, the probable error being about two seconds of arc, or 130 feet.

Meanwhile Captain Featherstonhaugh, who had finished the observations for latitude at North Pembina, took his party to Lake Roseau, which is about 60 miles east of the Red River, in order to establish an astronomical station, and mark the boundary in the vicinity. Between the Lake of the Woods and Pointe d'Orme on the Roseau river, mentioned just now, there are, on the boundary, about 50 miles of almost continuous swamp, in the midst of which are ridges covered with valuable pine timber. Some firm ground was reported to exist on the shores of Lake Roseau, which was represented on the maps as being intersected by the boundary. Captain Featherstonhaugh and party, accompanied by a guide, after a long detour to the south to avoid being entangled prematurely in the swamps, reached the lake and found that the parallel was 6 miles north of it. After some trouble, a gravelly ridge was discovered to the northwest, which was sufficiently near to the parallel of 49 deg., and the astronomical instruments were set up here on the 27th October. Considerable advantage was derived in getting through the soft parts of the journey from the presence of a pair of oxen amongst the teams. These animals, though apt to be looked upon as encumbrances when they are in company with horses because they travel slowly, and can only do 15 miles a day, will take a load through bogs, in

which the latter are quite helpless. On the 17th, an aurora of remarkable brilliancy was observed at a place 8 miles south of Lake Roseau; besides the usual bow and streamers, an arch of light about two degrees wide was formed passing through the zenith from east to west. A constant wave or pulsation of luminosity advanced from the eastern end of this arch and travelled slowly by successive impulses along it. The effect lasted about three quarters of an hour, and although there was a very bright full moon, the aurora quite held its own in vividness.

A few Chippewa Indians were seen about here, but they appeared to be an idle set, without anything striking in their appearance or bearing. They subsist chiefly on fish caught in the lake, a resource which does not always keep them from want.

After completing the observations for latitude, Captain Featherstonhaugh set his men to cut east and west tangent lines (*i.e.*, straight lines tangent to the parallel) through the woods, the intention being to cut about ten miles to the east, and then to work westward as far as Pointe d'Orme. It was soon found, however, that the muskegs or swamps which lay to the east were so continuous that progress during the open season would be very slow indeed, and it was resolved to work only westward, in which direction the trees were much larger, and there was some sort of foothold to be obtained. These muskegs are four or five feet deep in many places; they have on the surface a skin of sod which scarcely supports the weight of a man, and when it is pierced the muddy water rises in the hole nearly to the top. A person breaking through goes down to his middle, and has some trouble in getting out again. The westerly line being continued, considerable difficulties were shortly experienced in the work, the frost which set in on the 10th November having been unfortunately preceded by snow, which for some time prevented the ground from freezing. The men were unskilled in the use of the axe, and the swamp-holes between the trees, which it was impossible to avoid, kept them constantly half wet through. This, with the thermometer at zero, or but a little above it, could not fail to be a serious thing, and, besides the direct suffering from the cold, many were attacked with diarrhœa, one man becoming dangerously ill with congestion of the liver. Anxiety was always felt also as to the safety of the supply teams, which had to traverse 100 miles of open country, where a snowstorm might prove dangerous. The cutting, however, was continued, and after about 4½ miles had been completed through the spruce and tamarac, the party, to their great satisfaction, emerged on to the open surface of the great Roseau swamp. This was then just frozen over, and, as far as the eye could reach, the glare ice stretched away to the horizon towards the south and south-west, with small tufts of grass here and there, and thin wreaths of snow curling up before the wind that swept across it. Desolate as the aspect was, the change was welcomed from the wet and fatiguing work in the woods, and the line was quickly taken across the open, the sick man being sent back to head-quarters, and the guide directed to find a direct road along the parallel from Pointe d'Orme. A day or two of the great cold now set in, giving the finishing touch to the swamps and rivers, and causing the party to

wish for the shelter of the woods again. On days like this, when protected from the wind, any one will get along tolerably well, though the thermometer be 20 deg. or 30 deg. below zero, but the slightest breeze produces great discomfort, and it is very difficult to pay the proper attention to surveying operations. On several occasions the eyelids would feel as if they were about to be frozen down, the ends of the lashes becoming tipped with ice; the first realization of this produces unbounded surprise to the person concerned.

About the middle of December, Captain Featherstonhaugh's party struck the end of a line which Mr. Russell's men had cut for a distance of six miles westward from Pointe d'Orme, and the Lake Roseau astronomical station was thus connected in longitude with North Pembina. There still remained nearly thirty miles immediately west of the Lake of the Woods, over which the line had to be traced, if possible. Colonel Forrest and his surveying party who had traversed the shore of the lake from the north-west angle southwards to the Buffalo point astronomical station, were now at work cutting from the latter place westward, but no news had been received of their progress. Major Cameron becoming, however, anxious as to the welfare of those in the field, desired that the work should cease, if the exposure was likely to continue so severe, and Captain Anderson, who had just completed the observations for longitude at Red River, set out for Pointe d'Orme with Mr. Herchmer, the commissary, in order to be able to report upon the advisability of persevering. Upon conferring with the officers who were at this place, it was concluded that the work could go on, the principal astronomical observations being finished, and the health of those concerned having been good since the ground had all become frozen. In accordance with this opinion, measures were taken at head-quarters to stock depôts at Pointe d'Orme and at Pine River, north of Lake Roseau, and parties of axemen were sent to construct a log hut for this purpose at each place, stables being also commenced at the former spot.

The survey of the 6-mile belt north of the boundary was now continued towards Pointe d'Orme, and the line which had been traced across the prairies from Red River to the same place requiring to be checked, the two astronomical parties commenced this work. Unfortunately the weather became colder and colder, the thermometer registering 51 degs. below zero of Fahrenheit on the 23rd of December, and it became difficult to take the most simple observations of stars for azimuth with the proper precision, owing to the freezing of the lubricating oil in the internal parts of the instruments, and of the oil in the lamps illuminating the field of view. Lieut. Galwey's party, being on the perfectly open prairie immediately east of the Red River, were particularly exposed during this severe spell.

About the end of the year, no news having been received for some time from Colonel Forrest, who had hitherto drawn his supplies from the government depôt at the north-west angle of the Lake of the Woods, Captain Anderson, with a dog train and some provisions, set out for Lake Roseau, and travelled up the East Roseau River to the 49th parallel. Colonel Forrest was found to be about five miles to the east, and having relieved the wants of his party, Captain

Anderson returned towards Pine River, and was met whilst on Lake Roseau, by the terrible storm of the 7th, 8th, and 9th of January, which prevailed over the whole of Manitoba and Minnesota. For three days, with the thermometer at 20 deg. below zero, the wind blew with extraordinary force, raising mists of fine snow from the surface, so that the air became of a milky opacity, and objects were invisible at a few yards distance. In Minnesota* eighty persons were frozen to death, many of them being children on their way home from school; and a coach-load of passengers, as well as the horses, suffered the same fate. Captain Anderson and those with him took refuge in one of the small islands of poplar near the shores of the lake, and being able to keep a fire alight, escaped without harm. The parties at work on the prairie fortunately took the alarm in time, and got back to their camps; but two men, one of them a sapper, who were driving in a waggon a few miles from North Pembina, were obliged to come to a halt, cut the horses loose, and remain wrapped in their buffalo robes for two days and nights inside the waggon, without food or fire. They eventually reached head-quarters without having suffered serious injury.

After this, for the remainder of the winter, the weather was fine, and the lengthening days and bright sun made matters more cheerful; but the cold continued steadily until the equinox, the thermometer falling as low as 40 deg. below zero even as late as the 1st of March. The parties, however, being now well sheltered, were more comfortable than would be imagined. The perfect stillness of the woods disarms the most extreme cold of half its severity, and the dark green foliage of the fir and pine is a pleasant relief to the eye, where all else is an endless glare of white. The spruce boughs laid on a waterproof sheet, furnish dry and comfortable couches on the surface of the snow itself, and an ample supply of good firewood is found on the outskirts of the growing timber. At night the trees, under the influence of the frost, crack with surprising loudness, the effect being like that of pistol shots heard at a little distance. Canadian grouse and prairie fowl are tolerably numerous; they sun themselves on fine days, sitting on the tops of the trees; they feed on berries, and are in fairly good condition. Butcher birds and woodpeckers are also seen, and the snow is covered in many places with the tracks of rabbits. Large game are very scarce; even the Indians never seemed to find any moose, though one or two were known to be about Lake Roseau.

Mock suns and mock moons were frequently seen, and on one occasion two mock Venuses were visible. This is believed to be a rare occurrence. On these occasions the air was observed to be filled with floating spiculæ of ice, which settled gradually down when they attained a certain size. Sometimes just after dawn a peculiar effect was observed, due to the presence of these spiculæ. From the point of the horizon above the yet unrisen sun, a prismatic beam of light extended 30 deg. or 40 deg. towards the zenith, and to the right and left two similar beams, only not so vivid, reached nearly the same altitude. The three beams stretched higher and higher as the sun approached the horizon, until the

* This number is given in the United States official account of the calamity.

real and the two mock orbs rose together, each sending the prismatic rays both upwards and downwards. The effect gradually faded away after this as the day advanced. After Christmas, snow shoes came into general use, the men soon learning how to walk in them; indeed there is little difficulty in doing so. It is a mistake, however, to suppose that these contrivances enable a man to travel over snow with as much ease as he would over grass. In some cases where a track is partially beaten, or in the spring of the year when there is a crust on the surface, very quick walking can be accomplished by their aid, but under ordinary circumstances, all that a snow shoe does is to enable a man to progress slowly where, without them, he would not get on at all.

During February and March, the remaining portions of the boundary between the Lake of the Woods and the Red River were cut through the woods and temporarily marked with posts of 8 in. diameter. The survey of the 6 mile belt north of the line was also completed, and nothing remained to be done in this part of the country except the putting up of the iron pillars and permanent monuments. This was postponed until the next year.

By the 1st of April the parties had all returned to North Pembina, where they were lodged in quarters which had been built by a contractor from Fort Garry during the early part of the winter. These buildings, which were named "Dufferin," are situated on the left or western bank of the Red River, about two miles north of the boundary; they can accommodate about 11 officers, 80 men, and 180 horses or oxen. There are also three stores, containing 5,000 square feet of flooring, and a bakehouse capable of baking 200 loaves (of 1½ lbs.) in one batch.

During the next six weeks, preparations were made for the summer season's work, for which the necessary supplies had been ordered from St. Paul in Minnesota, U.S. Mr. W. Boswell, the veterinary surgeon, brought from Ontario in Canada a train of 180 horses for the commission. After leaving the railway at Moorhead, they were taken up the coach road along the banks of the Red River; but this stream having risen about 30 feet, as is usually the case in spring, had so flooded the country that men and horses had to be constantly swimming the numerous coulées or watercourses which run into the main stream. After a laborious journey, the train arrived safely at Dufferin.

The United States commission arrived at Fort Pembina, U.S., at the end of May, and a plan of operations was agreed upon for marking the boundary across the prairies. The following was the general arrangement:—The latitude was to be determined by astronomical observations at intervals of 20 miles along the parallel, and the points so determined were to be connected by surveyed lines. In taking 20 miles as the intervals between the astronomical stations, the time of observing at each station, and the time of connecting two stations by survey, had to be considered as well as the relative accuracy of each operation. With the zenith telescope, the time occupied in determining the latitude of each station might be assumed as 7 days on an average, three clear nights being sufficient for the observations.

The connection of two astronomical stations was effected by laying off a line

from one of the stations at right angles to the meridian, and prolonging this line until it struck the meridian of the second station, the whole distance being chained, and pickets left in the ground. The proper offsets to the parallel were then measured wherever permanent marks were intended to be erected. The average progress of such work was 5 miles a day; so that of two separate parties, one running the line as it was called, and the other observing for latitude, the former would complete its work first. But in the British commission, the astronomical party had to do both, so that the time question was not of such direct weight, although it was of course evident that the fewer the astronomical stations the quicker would the whole work be done.

This was a reason for not putting the stations closer together than 20 miles; but other considerations prevented their being placed much further apart. The probable error, that is to say, the measure of accuracy of the determination of the latitude of a station by the zenith telescope, was expected to be about 10 feet, and, as a matter of fact, it was rarely found to be greater, and in most cases less. The error in laying down the direction of the line might be assumed at 5 seconds, which would produce a deviation of $1\frac{1}{3}$ inches a mile, or $2\frac{1}{2}$ feet in 20 miles, and the error of prolonging the line was expected not to be greater than one minute of azimuth at the end of 20 miles, which would be equal to a deviation of 30 feet. It may be remarked, however, that the error in running the line was very rarely more than 30 seconds at the end of 20 miles, and generally less.

About two thirds of this latter deviation could be got rid of by taking fresh observations for direction and correcting the intermediate pickets, so that there remained 10 feet of uncertainty in the position of any point on the latter portion of the line; that is to say, the determination of all the intermediate points by survey was as accurate as if astronomical observations had been taken at each of these points, supposing the direction of the plumb-line to strike the earth's surface at the same angle over the whole span of 20 miles; or, in case of any variation, supposing it to vary regularly from one end to the other. (See the remarks in the Appendix on the deviation of the plumb-line.)

If the stations had been at a greater distance apart, say 30 miles, the deviation in running the line would have been, of course, one half greater; it would have been often necessary to go back to correct errors, and the work would have been altogether less manageable. Other reasons for the interval adopted were, that it was considered desirable that the different parties should not be more than a day's march from each other, and that the whole commission should not cover more than a certain span of country at any one time.

The adopted interval of 20 miles was of course not rigidly adhered to. Astronomical stations were placed at well marked natural features, such as the banks of rivers, the edges of mountainous districts, &c., irrespective of the precise mileage in longitude, but the average of 20 miles was observed throughout the first summer's work. This average was increased to 21 miles during the last summer's work, because this number was a measure of the whole distance that remained to be done.

The permanent marks along the boundary were agreed to be placed at intervals of one mile between the meridians of 96 deg. and 99 deg. west longitude, which are the east and west limits of the province of Manitoba, and at intervals of three miles in the country west of 99 deg. The former set of marks were to be iron pillars firmly fixed in the ground; the latter were to be mounds of stones wherever these could be procured, or, failing them, of earth.

Drawings of the iron pillars are given in Pl. X.

It was further agreed that the astronomers of the two commissions should take alternate stations, each party making good the connecting survey up to that 20 miles west of it. An exception was made in the case of the first two stations west of the Red River, at which the astronomers of both commissions took independent observations. The surveyors covered a width of six miles north and south of the line, the British and American parties working each on their own side. Table 3 gives a detail of the British parties, shewing their transport and camp equipage.

The nature of the boundary extending for a long distance across an uninhabited and unknown country in which no supplies would probably be obtainable, the shortness of the summer season, and the scarcity of wood and water, combined to render it necessary for the work to be done with as much expedition as was consistent with efficiency; at high pressure, so to speak. Under such circumstances, it was desirable that the astronomical parties, whose progress regulated that of the whole commission should not be delayed even for a day by having to explore for water or to take preliminary observations before setting up the zenith telescope, which it was desirable to place as nearly on the 49th parallel as possible. It was also necessary that depôts of provisions should be established without delays at the proper intervals, and that the roads to these depôts should be practicable for heavy teams. It was evident that mismanagement or mistakes on these points would produce great delay and extra expense, and a reconnaissance party was accordingly formed, consisting of 20 scouts—mounted men—with sufficient transport to carry food for a fortnight, if necessary. Captain Anderson, who, as chief astronomer, was in charge of the field operations of the commission, adopted the plan of taking this reconnaissance party on ahead of all the others about 100 or 150 miles along the 49th parallel, making a sketch of the country as he travelled, and keeping his course by sextant observations for latitude and time. Having with him four mean-time pocket chronometers, whose rates were known, he obtained the longitudes of particular points with sufficient accuracy to enable him to mark on the ground the sites for the astronomical stations at the average intervals of twenty miles, and to select and map down the positions for the depôts where water was permanently to be found. On returning to the starting point of the reconnaissances, the travelling rates of the chronometers were checked by the local time, and in this way very accurate sketches were prepared, tracings of which were furnished to the officers in charge of the different parties, so that they were always well informed as to the nature of the country they were about to traverse. By this means also, an early knowledge of the main features of the

six-mile belt being acquired, the amount of survey work that would have to be done was estimated, and the necessary arrangements made.

By the first week in June, both the commissions had set to work, and the boundary was marked across the western side of the Red River valley as far as Pembina Mountain, which is a sudden rise of about 300 feet in the prairie level, and is really a sort of step or escarpment, having no western edge, only an eastern one. Being, however, intersected, where the boundary strikes it, with numerous ravines which stop the prairie fires coming from the west, it is covered with timber and bush, and has the appearance, as seen from the east, of a mountainous ridge. One of the British astronomical parties detached part of its complement to cut and trace the line through the eight miles of wood which occur here; while the main bodies of the two commissions, diverging round the north and south edges of the timbered land, crossed the Pembina River, and took up astronomical stations across the sixty miles of prairie which intervene between it and Turtle Mountain, where a site for a depôt had been selected by the British reconnaissance party.

Turtle Mountain is a well wooded district, consisting of numerous small hills, which gradually rise to as much as 500 feet above the plains, and are covered with poplar, birch, and oak. Between these hills are countless swamps and lakes, the water being unable to get away. The shape of the mountain, as seen from the west, is very like that of a turtle, a smaller detached ridge representing the head, and the name is derived from this resemblance. At the middle of July, nearly all the British and United States parties were assembled round the north-eastern skirts of the mountain, and the escort of cavalry which accompanied the United States commission was also encamped here. Grass, fuel, and water were abundant, but the plague of flies was almost intolerable; the horses, which could not feed properly, suffered considerably in condition, and all hands had to wear mosquito veils and gauntlets. The number of mosquitoes in the summer in these countries is quite incredible, and the reality is worse than the anticipation. It may suffice to say that oxen have been known to be choked by them, and that on a still warm night the noise they make beating against the outside of a tent, resembles that of rain. The only time that there is any relief from them is in the middle of the day, when the heat of the sun prevents their appearing; a moderate breeze will also keep them quiet.

The 1st British astronomical party which had established the point where the boundary enters the mountain from the east, was charged with taking the line into the interior, working westward. One of the United States parties travelling round the north side of the woods, determined the position of the 49th parallel on the western edge of the mountain, and commenced to cut in an easterly direction, so as to meet the others half way. The dense growth of poplar and bush which were met with on both lines, and the frequent swamps and pieces of water which the boundary traversed, caused this work to progress but slowly; roads or bridle paths had to be cut round the impassable portions, and the soft places "corduroyed," to enable the pack animals to get over them. The interior of the mountain is, however, singularly beautiful, owing to the

graceful outlines of the hills, covered with leafy poplars, and the perfect stillness of the lakes, the shores of which are clothed with foliage down to the water's edge. From a high point in the cutting about three miles from its commencement, the mounds, marking the 49th parallel on the prairie to the eastward, could be seen stretching in a gentle but well defined curve for a distance of 15 miles, thus giving the spectator a very graphic idea of the size and figure of the earth.

Seeing that the work of cutting through these woods would be a tedious but practicable operation, Captain Featherstonhaugh divided his party in two, and taking with him about ten men and his astronomical instruments, started for the plains further west, leaving the remainder in charge of Mr. W. F. King, sub-assistant astronomer, to continue the cutting and tracing of the line to the halfway point. As matters fell out, however the United States party who were working eastward, met at the end of 10 miles with such large lakes, that although they crossed them and marked the line on the eastern margin, they went no further, and Mr. King, to complete the work, had to carry on his cutting for 24 miles, which he finished at the end of September.

Meanwhile, the reconnaissance had been carried 150 miles further west, and the astronomical parties of both commissions had taken up their stations across the plains for nearly this distance. The Souris River which runs through about 300 miles of this country, was crossed by the boundary four times, and proved a great resource to the expedition. This stream, which is scarcely entitled to be called a river, if its width and volume of water are considered, flows for most of its course at the bottom of a valley averaging a mile in width, with high and steep banks. The actual watercourse is fringed with oak and poplar, which supplied the parties with fuel. Above the third crossing, however, the trees disappeared, and this spot, which was the site of one of the principal depôts, was named Wood End in consequence. The work advancing steadily by 20-mile spans, reached this point at the end of August, and Lieut. Galwey, R.E., took up an astronomical station at the foot of the Grand Coteau, which here crosses the boundary in an oblique direction. This remarkable range of hills runs for some hundreds of miles across the plains from south-east to north-west, starting from latitude 44 deg. near the Missouri, and extending far into the British territories. From a little distance it resembles a well defined coast-line seen from the sea; it is, like the plains at its foot, perfectly bare of trees, and looks, perhaps, even more desolate than they do. The interior of the Coteau has been aptly described by Mr. G. M. Dawson, the geologist and naturalist of the boundary commission, as a "confusion of abruptly-rounded and tumultuous hills," the tops of which are stony; but the sides and the small basins between them have some good soil, and there are numerous swamps and lakelets. At the time that the boundary commissions entered the Coteau, the grass over the whole country was beginning to burn, and it was with some difficulty that the different parties obtained pasture. The autumn fires, driven by high winds, sweep over the surface with great rapidity; and although, from the shortness of the grass in these latitudes, there is not much actual danger to life, the tents of

a pitched camp may very easily get burnt if a good look out be not kept. One of the astronomical parties, caught by a change of wind, was regularly "stampeded" one day when on the march; the other, from the same cause, had a desperate fight with a fire they had themselves lighted to leeward; and one of the surveying parties had to tear down their tents and get everything across the friendly stream of the Souris, losing some of their clothes in the process. Getting clear of the Coteau, which is about thirty miles wide, the different parties were on the prairie once more; but they had passed the watershed, and the streams now flowed south to the Missouri. However small these might be, they had one quality, which the stagnant Souris had lacked for so long—they ran—and the difference was very welcome. Some wood also was found in the big ravines, and the members of the commissions had began to congratulate themselves on being in a more comfortable part of the country, when on the 22nd of September a snowstorm of the same violence and suddenness as that which occurred at Red River on the same day in the preceding year, burst upon them. At this time the different parties were at or on their way to their final stations for the year, and every day was of importance, considering the long journey of 400 miles that they had to make back to the settlements. The storm, however, put a stop to all work for nearly a week, and those who were fortunate enough to be near any ravines, took shelter in them; this weather was particularly severe upon the horses, which had to be kept tied up to prevent their running away, it being difficult to find for them any grass long enough to cut. Horses when exposed to these storms, will, if they get loose, run for miles straight before the wind, and it is necessary to tie them up securely, to avoid losing them altogether.

After the weather had moderated, there remained one or two weeks' work before turning eastward, and Captain Anderson, after making arrangements for the provisioning of the parties of the British commission during this time, started on the fifth and final reconnaissance of the year. Reaching station No. 23, which was at the 408 mile point from Red River, on the 2nd of October, he pursued his journey westward for about thirteen miles, and on attaining the summit of a high ridge running north and south, came suddenly on the eastern edge of the "bad lands." These extraordinary surfaces are due to the rapid waste of the soft clayey tertiary formations by the melting snow water and the rains in the spring of the year. Steep irregular hills of clay, to quote Mr. Dawson again, on which scarcely a trace of vegetation exists, are found, separated by deep, nearly perpendicular sided, valleys, which are furrowed from top to base by innumerable runnels, converging into larger furrows below; the scarred and seamed conical masses, and the glare of the white clays of which the whole surface is composed, give a very peculiar aspect to the landscape. Progress with wheeled vehicles was here quite impossible without more road-making than there was time for; but the 430 mile point was reached on horseback, and the site of station No. 24 was selected and marked as the first of the ensuing season.

From this point Captain Anderson turned northwards, in order to reconnoitre

a site for a principal depôt amongst the valleys of the Woody Mountain range, which is about twenty miles north of this part of the boundary. Reaching the summit of these hills, an extensive view was obtained of the surrounding country; to the west, a wide and precipitous ravine appeared to cross the line at a distance of about fifteen miles, while to the north was a level plain, stretching to the horizon. The ravines below the feet of the party were well wooded, but were now filling up with drifted snow, and some buffalo were seen taking refuge in them. Turning eastward from this wild spot, Captain Anderson proceeded to explore the hills, in order to find the camp of the Half-breeds, who were known to spend the winter in one of the valleys. Some Sioux Indians, who were met travelling towards the south, pointed out the right direction, and the place was reached after a day's journey. About eighty families of Half-breeds, who migrated from the Red River valley, form a sort of settlement here in the winter time, residing in huts. In the summer they abandon their dwellings, and go out on to the plains near Milk River, taking their women and children with them, it not being considered safe to leave them unprotected at Woody Mountain. Having found a suitable site, with wood and water, for a large depôt for the next season's work, and having determined its latitude and longitude, Captain Anderson started for the Red River on the 8th of October, and gathering up with him on the way all the survey parties, depôt keepers, etc, who still remained in the field, he reached Dufferin on the 31st of October, the two astronomical parties and some of the others having arrived shortly before.

Thus ended the first summer's work, during which the two commissions had established twenty-one astronomical stations, and chained and marked 408 miles of the boundary, of which 43 were cut through woods. The country had also been surveyed for a width of 6 miles north and south of the boundary, each commission working on its own side. In the case of the British parties, the width of 6 miles was extended to 15 in some places, and they traversed, with the theodolite and chain, 857 miles, covering with their work a total area of 3,004 square miles. The chained and marked tangent lines were used as bases for the survey, and the traversing along the important watercourses was in all cases commenced from and closed upon them.

The commissariat arrangements during the season may be briefly described. The total length of the line of work was 408 miles in longitude, and about 430 by the actual routes travelled. Along this distance four principal depôts were established, viz., at Pembina Mountain, Turtle Mountain, second crossing of the Souris, and Wood End, the intervals from one to the other being about 90 miles. Provisions were hauled to these depôts by the commissariat horse-trains of 30 Whitewater waggons, and by a hired train of 17 Red River carts. Sub-depôts were made between the principal ones, viz., at Long River, at the first crossing of the Souris, and on the Grand Coteau. These places were chiefly used for storing oats and small quantities of rations for the teamsters of the supply trains as they passed to and fro.

Each party had one or two special waggons told off to it for keeping it sup-

plied with food. These waggons travelled backwards and forwards from the party to the nearest depôt.

Rations.

The ration of food allowed to each man was :—

1½ oz. apples (dried) ..... daily.	½ oz. pepper.. ..... daily.
4 oz. biscuits ..... „	½ oz. salt ..... „
16 oz. flour ..... „	⅔ oz. soap ..... „
(4 lbs. of baking powder to every 100 lbs. of flour.)	3 oz. sugar ..... „
2½ oz. cheese ..... daily.	$\frac{1}{100}$ gal. syrup ..... „
1 oz. oatmeal ..... „	1 oz. tea ..... „
$\frac{1}{200}$ gal. pickles, or ¼ pint of vinegar..... weekly.	½ oz. tobacco ..... „
16 oz. meat ..... daily.	½ oz. mustard ..... weekly.
	4 oz. beans (dried) .. .. daily.
	Matches as required.

All these articles were not issued daily to each man, but these were the relative proportions allowed. The total weight of food per day was about 40 oz.

For each horse the daily allowance was 9 lbs. of oats; the Red River ponies received none during the summer.

For the use of the animals on the journey homewards, hay stacks were made at certain spots, at intervals of about forty miles; but, unfortunately, some of these were destroyed by the prairie fires.

The operations of the commission for 1874 were arranged to be carried on in a very similar manner to those of 1873. Depôts were to be established in succession at intervals of 80 miles, from which the parties should draw their provisions. As the work, however, would commence at a point 430 miles from the Red River, and constantly recede still further, it was necessary to have a new base upon which the expedition could rely for the summer and autumn of 1874, and also for the ensuing winter, should any work remain to be done during 1875. Woody Mountain—where there was an ample supply of wood, and where pemmican and dried buffalo meat could be obtained, if required—was chosen as the new base, and a contract was made with a merchant at Helena, in the State of Montana, U.S., for the supply of 29,000 bushels of oats, to be delivered by him at the mountain on the 15th of June, 1874. A large number of additional waggons and draught oxen having been purchased, (see the Tables), five months' provisions for the whole expedition were packed early in May, and at the same time the parties were equipped and went under canvass, ready to start as soon as the grass should be long enough for the animals to feed on it. The two Canadian gentlemen who had filled the posts of surveyors during 1873, having retired from the commission, Lieut. Rowe, R.E., who had arrived from England in August of that year, and had taken part in the astronomical work in September and October, took over charge of the surveying operations, and the three survey parties were amalgamated into one under him. The six-mile belt of survey from Woody Mountain up to the Rocky Mountains, was ordered to be reduced to three miles.

Preceded by a road-making detachment, which bridged the streams and corduroyed the swampy parts of the last year's trail, the parties of the commission left the Red River on the 20th of May, under the charge of Captain Anderson, and on the 3rd of June found themselves on the banks of the Souris River, which at this time of the year was 55 yards wide, and 7 or 8 feet deep. As there were more than 100 waggons, spring carts, etc., and large quantities of stores, it was thought advisable to bridge the stream, which was done by constructing cribs of wood, which were sunk at suitable intervals, and which carried the superstructure. Having crossed over, the commission parties pursued their journey somewhat more rapidly than before, the oxen improving daily in condition and travelling power, when on the 11th of June a most unfortunate accident happened to Lieut. Rowe, who, by the falling of his horse, was so severely injured, that it was considered unsafe to move him from the spot for some days. Dr. Burgess and Captain Ward remained with him until he was able to be taken on to Woody Mountain, six weeks afterwards.

The train, proceeding on its journey, arrived at the foot of the Grand Coteau on the 13th of June. Here the two astronomical and the surveying parties were detached, and followed the old track along the parallel across the Coteau; the remainder, with the commissariat train, took the Trader's road, which runs in a north-westerly direction along the foot of the hills to Woody Mountain. On the 20th of June, just a month after leaving Red River, the parties commenced work at their respective stations, and about a week or ten days later the United States' commission which had come up from the line of the Missouri River, appeared on the parallel, and at once commenced operations, so that by the 5th of July three astronomical stations had been established, and 80 miles of boundary had been chained and marked. In this part of the work the great ravine of Frenchman's Creek, or White Mud River, was crossed. This immense trough is 6 miles wide and 320 feet in depth below the prairies on either side; its eastern edges are precipitous. The whole floor of the valley is cut up into gullies and slopes of shale, and the stream itself rushes over a pebbly bed in a smaller ravine at the bottom of the big one. No passage for wheeled vehicles could be found down these cliffs on the line, and the British parties had to use a pass about 16 miles to the north, the United States' commission finding one almost the same distance to the south. Getting clear of this obstacle, the two commissions with their next stations covered the plateau which extends from Frenchman's Creek to Milk River; the surface of this plain is composed of white clay, in which the grass grows sparingly, and in which water is very scarce. At this time of the year, in the height of summer, the direct heat of the sun, aided by the reverberation from the soil, was oppressively great, and the aspect of the country was more like a desert than any that had been previously traversed. The supply of wood now totally failed, and the cooking was done by using the buffalo chips, which lay scattered in great profusion over the ground; strange to say, however, it was here, where game appeared to be least likely to be found, that the buffalo were first encountered. In July, when the pools of water are fast drying up under the sun, and when the grass of their

more southern pastures has been consumed, these animals make their way northward to the fertile valleys of the Saskatchewan and its tributaries. They appear to cling to the line of the Milk River, probably because they depend upon its water. With the buffalo were found their constant attendants, the Indians, both Sioux and Assinebonies. These people were well clothed and armed, and appeared to have plenty of food; they always begged for a small quantity of tea, sugar, and flour, and were particularly keen after matches, which they evidently valued highly. They asked numerous questions about the objects of the expedition, and appeared relieved to hear that no idea of a railway lay at the bottom of it. As far as could be known, the fact of a boundary being marked between the British and American territories seemed to be welcome to them, and it is said that they were rather disappointed that a wall or continuous bank was not set up across the plains, a thing which they had been led to expect. It was on this clay plateau also that in the middle of July an extraordinary swarm of grasshoppers was met with; the ground was covered with them, and the air was so full of them, that the appearance was exactly like that of a snow storm, to which they have often been compared by travellers.

Reaching the Milk River, which Captain Anderson had reconnoitred for forty miles of its course before finding a crossing place, the commissions passed by a large camp formed by the Half-breeds from Woody Mountain and from the valley of Frenchman's Creek. There were about 200 tepees or tents, each containing a family, and it was estimated that there were 2,000 horses, ponies, etc., belonging to the band. The camp was a large rectangle, the sides of which were formed by the tents and carts, and the animals were driven every night into the enclosure thus provided. These Half-breeds are educated to a certain extent; they profess the Roman Catholic religion, and there was a priest with them at this time; they keep up a sort of military discipline founded on mutual consent, and the necessity of defending themselves from the Indians; outlying videttes are regularly maintained at some miles from the camp, so as to give early notice of the approach of any party sufficiently numerous to be formidable to them. In the summer time these people hunt the buffalo for the sake of its flesh, which they dry or convert into pemmican; in the autumn and early winter they kill them for the sake of the skins, which are taken during the ensuing spring to the Missouri and to Fort Garry, where they are exchanged for groceries, clothes, and ammunition.

Crossing the Milk River at a point about eight miles south of the line, the astronomical parties took up their stations over the country between the gorge of this stream and the West Butte. The valley of the Milk River is another of those rugged and impassable troughs cut out in the soft cretaceous formations by the action of water; it is about a mile wide and 300 feet in depth, the sides being precipitous and of a dark and gloomy tint. There are numerous tributary ravines, which enter the main gorge at right angles; these contain narrow buffalo paths, along which the herds pass in search of water, or in order to cross to the north. The stream itself winds from side to side of the bottom of the valley, and is fringed with timber where the boundary strikes it. The survey

party, unfortunately still deprived of the superintendence of Lieut. Rowe, but very ably directed by Mr. W. A. Ashe, sub-assistant astronomer, had here a hard piece of work with the traverse of the tortuous watercourse and the rugged cliffs on each side of it; they carried it, however, to a distance of ten miles up stream, the general course of the river coming from the west after a few miles northing.

The plains between Milk River and the Three Buttes are a sort of neutral ground between the Indian tribes, and are generally left unoccupied by them; the Sioux and Assinebonies do not appear to cross to the west bank of the stream, and the Blackfeet, who cling to the skirts of the Rocky Mountains, rarely approach the Buttes. As a consequence, perhaps, of this state of things, this strip of country was, in July, 1874, full of buffalo, which were slowly moving north in large herds; from them the different parties obtained ample supplies of fresh meat, which, although not equal in quality to the flesh of the deer and antelope, was preferable to the hard beef that the much travelled oxen afforded. On this part of the boundary, and on this part alone, rattlesnakes were found; they were not numerous, but were tolerably large; they lived in holes on the open plain, and always seemed to get out of the way without attempting to strike even when a horse stepped over them by accident. The rattle they make is very rapid, and appears to fill all the air without coming from any particular spot; it resembles the sound of a pot boiling over.

At the end of July the two commissions were all encamped round the foot of the Sweet Grass Hills; Major Cameron and the United States' Commissioner, Mr. Archibald Campbell, both passed on their way to the Rocky Mountains about this time, and the work was made good up to the westernmost Butte on the 30th of July. These isolated masses, called on the maps the "Three Buttes," but known by the hunters and Half-breeds as the "Sweet Grass Hills," are three distinct peaks, which rise to a height of 3,000 feet above the plains at their feet. Seen from the north, they have a grand and majestic appearance from the contrast they present to the monotonous level of all the surrounding country. Their sides are clothed with pine timber, and numerous springs issue from them; the water from these running down in small rivulets on to the plains is soon swallowed up by the arid soil. At a short distance to the north of the boundary here, the bodies of about twenty Crow Indians were found who had been killed by the Blackfeet in the preceding autumn. It appears that the vanquished party had stolen some horses from the others, and, being pursued, had been overtaken before they had reached the shelter of the hills; small rifle pits had been scratched up by them in haste when they had had to turn and fight, but they had been overpowered. The bodies had been stripped, scalped, and hacked about a good deal; there were one or two very large men amongst them.

From some high ground near the West Butte depôt the Rocky Mountains could be seen lining the western horizon, the snow and ice on their summits being clearly distinguished in the morning sun. The reconnaissance party pushing on to St. Mary's River, which is about twenty miles from the mountains, found a suitable site for a depôt and an astronomical station between them and

it, and the commissariat train were at once sent on to this spot with thirty days provisions for the working parties. The distance from the West Butte was about 80 miles. During the first half of August the astronomical stations and tangent lines were completed across this span, and the survey party commenced the traverse of St. Mary's River, their work being extended again to a width of six miles north of the line, for the remaining part of the boundary. A further reconnaissance shewed that the 49th parallel, striking an immense mass called Mount Wilson, passed over the crest of it, and intersected on its further side a large piece of water called Waterton Lake; it then followed an inaccessible ravine for about nine miles, till it reached the watershed ridge, on which a monument had been erected by the Boundary Commission of 1861. It was agreed that the British astronomical parties should take up two stations, one at the point already mentioned at the depôt west of St. Mary's River, and the other on the eastern flank of Mount Wilson, the tangent lines being traced and chained up to the latter. The United States' Commission were to determine the position of the boundary on Waterton Lake, and the connection, in longitude, with the terminal monument of 1861 was to be effected by traversing round the northern side of Mount Wilson and up the Kootenay Pass. Major Cameron indeed endeavoured to find a direct route along the boundary from Waterton Lake westward; but although he nearly reached the terminal monument, he could not quite do so, and it was evident that chaining would be impossible except up the pass. In accordance with these arrangements, the three last stations of the work were established in the third and fourth weeks of August, some triangulation having to be done from the zenith telescopes to the parallel, on account of the difficult nature of the country preventing the instruments being taken as near to the line as usual. It was now the end of the summer, but the weather was still clear and warm, and the beautiful scenery, amidst which the parties suddenly found themselves, contrasted strongly with the monotonous plains on which they had been working for so long. Instead of short and scanty herbage, the grass was now luxuriant and rich; clear and impetuous streams took the place of muddy and stagnant pools, and the eye was once more rejoiced with the sight of trees and foliage. Wild fowl and dusky grouse abounded, and the rivers were full of salmon trout of from 3 to 5 lbs. in weight.

The direction of the mountain range is from south-east to north-west; the boundary, striking it obliquely, passes about six miles north of Chief's Mountain, which stands out into the plains at right angles to the main chain; the line then crosses the immense mass of Mount Wilson, which fills up seven miles in longitude, and falls into Waterton Lake. This beautiful piece of water, which is 9 miles long and about 1 mile wide, lies between mountains, whose sides rise precipitously for 3,000 or 4,000 feet from the water's edge, and resembles somewhat the Lake of Lucerne, in Switzerland; the view also, from the top of one of the mountains at its northern end, is, in some respects, like that from the Righi. On one side nothing is seen but a crowd of mountain peaks filling the whole perspective; on the other, a level plain stretches to the horizon, and seems to differ only in colour from the sea. The lake, lying immediately below

the feet of the spectator, lends its beauty to the scene, and a unique grandeur is derived from the reflection that the mountains extend in unbroken series to the Pacific Ocean, 400 miles away, while the plains, bare and treeless, stretch for twice that distance in an opposite direction.

Following the Indian trail up the Kootenay Pass, Captain Anderson, with Mr. Dawson, the geologist, and the reconnaissance party, crossed the watershed into British Columbia, and coming upon the old trail of the Boundary Commissions of 1861, followed it to the terminal monument, which is situated on a very curious saddle-back, with precipitous sides, the mountain tops to the north and south rising straight up from it. Owing to its sheltered position, the monument was in perfect preservation, and a survey was carried back from it to the point where the Kootenay Pass trail crossed the watershed. Mr. Ashe's party, bringing their traverse up the pass from the plains, reached this point on the 27th of August, and the connection between the work of the two Commissions was thus completed. The United States' survey parties having triangulated from the north end of the lake down to the astronomical station on its western shore, connected the latter with the terminal monument by another route.

Meanwhile the two British astronomical parties had completed their last stations, and after about ten days spent in cutting through the dense woods on the foot hills of the mountains, and triangulating up the difficult valley of the Belly River, had made good the boundary up to the sides of Mount Wilson.

Nothing more remained to be done in the mountains, and after a day or two spent in visiting the Lake and the Kootenay Pass, the parties struck their camps and commenced their homeward march. It was not without reluctance that the beautiful and luxuriant scenery of the mountain valleys was left behind, and the dreary plains once more entered upon; but all knew how long a journey lay before them, and how suddenly and unmistakeably the winter might commence, so that, once started, the hope of getting back in good time was an efficient stimulus to travelling; the horses and ponies were also in remarkably good condition from their fortnight's repose and good living. The two astronomical parties were the first to leave, having still to put up the stone mounds as far as the commencement of the season's work; this was left to be done on the return journey, in order to economize time; they travelled along the line doing alternate parts of the work, and camping together at night. The buffalo were found in vast herds on the same ground as before, but appearing now to be stationary or inclining towards the south, and numerous as were the carcasses of those killed by the Indians and Half-breeds, the survivors were so countless, that the loss appeared insignificant by comparison. Captain Anderson with the survey and the reconnaissance parties, left the mountains on the 29th of August, and gathering up with him the depôt-keepers and men as he went along, followed the main trail back to Woody Mountain, which he reached on the 16th of September. There he was joined by the astronomical parties under Captain Featherstonhaugh and Lieut. Galwey, who had passed Frenchman's Creek by the southern crossing, and having erected the last of the stone mounds, arrived at the rendezvous on the 19th of September.

The united parties, numbering 167 officers and men, and about 200 horses and ponies, with 100 waggons, carts, etc., commenced the last half of the homeward journey together, under Captain Anderson; the Commissioner and Captain Ward having started back a short time previously, travelling light with two or three attendants only. The usual equinoctial storm was now daily expected, and other sources of anxiety were not absent, a telegram having been received, viâ Fort Benton, on the Missouri, to the effect that the Crees, who inhabit the country north of the line, intended to attack the Commission Train on its way eastward. Notwithstanding these expectations of unpleasant occurrences, nothing could have been more successful or enjoyable in its way than the march proved to be. The snowstorm did not come, the Crees kept their distance, and the weather remained warm and fine up to the very end. Haystacks had been made at the end of each probable day's march, near water, so that the animals were always well supplied with food during the night, without the risk of leaving them to graze after dark; and when they arrived at Dufferin, the horses, despite their march of 800 miles, were in perfect condition. Passing, in due course, the now familiar camping places of Wood End, the Souris River crossings, Turtle Mountain, etc., it was not without regret that they were left behind for the last time; and, despite the many disadvantages of the prairie and plains, there is no doubt that persons who have spent much time on them, acquire a sort of attachment to them that more pleasing landscapes fail to inspire. What the reason of this may be it is difficult to say; but the feeling is probably the same as that which a sailor has for the sea.

On the 11th of October the train reached Dufferin after a march of 860 miles by road, which had been accomplished in forty-three days, including halts.

The work done by the two Commissions in 1874 was as follows:—17 principal astronomical stations were established by observations with the zenith telescope; the connecting sight lines between the stations, extending over 339 miles, were chained throughout; a final span of 20 miles in the Rocky Mountains, which was impassable, was covered by traversing, and the country on each side of the line was surveyed for a total width of 6 miles up to St. Mary's River, and for a width of 12 miles between it and British Columbia. Meteorological observations were taken at the West Butte during the month of August, and barometer readings for altitude above the sea were obtained over the whole of the country traversed. Magnetic observations for dip and declination of the needle and for total magnetic force, were taken at Turtle Mountain, Wood End, the Three Buttes, and the Rocky Mountains; these observations, combined with those taken previously at the Lake of the Woods and at Dufferin, form a complete series, from which the curves of magnetic force have been laid down on the map of the country.

After the return to Dufferin, three small parties were sent out to put up the iron pillars along that portion of the boundary which forms the southern limit of the province of Manitoba. The sites of these pillars had been marked by temporary mounds and stakes by the British astronomical parties in the preceding spring; one half of the whole number of pillars having been set up, viz.,

every other one, the remainder were put in by the United States' Commission in 1875.

This completed the field work of the Boundary Commissions.

A. F.

POSTSCRIPT.

By Captain S. Anderson, R.E.

The foregoing paper has been limited to an account of the executive work of the Boundary Commission, and the names mentioned are those which naturally occur in the course of the narrative. It is the wish, however, of myself and the other R.E. Officers concerned to express here how much we were aided in our respective parts of the work by the Canadian Officers of the Commission. Without their thorough and efficient co-operation and assistance, the marking of the Boundary would have taken a much longer time, and would have been a much more arduous task to us.

The following are the names and appointments of the officers of the Commission nominated by the Dominion of Canada:—

Executive.—Surveyors.—Lieut. Colonel Forrest, of the Canadian Militia, P.L.S., and Mr. A. L. Russell, P.L.S. These gentlemen were in charge of surveying parties during the winter of 1872 and the summer of 1873.

Sub-Assistant Astronomers.—Messrs. G. F. Burpee, W. F. King, W. A. Ashe, and G. C. Coster were attached to the astronomical parties as assistants to the astronomers. They had charge of the computations, reductions, &c., and the subsidiary observations for time were sometimes taken by them. Mr. G. F. Burpee had charge of part of the surveying work during the winter of 1872. Mr. W. F. King superintended the tracing and cutting of the Boundary through Pembina Mountain and Turtle Mountain, the latter being a long and difficult work. Mr. W. A. Ashe had charge of all the surveying work in 1874 owing to the accident which happened to Lieutenant Rowe. Mr. D'Arcy East (late R.A.) was employed first as surveying officer, and latterly (1874) as Commander of the Scouts. With him was associated Mr. G. G. Crompton (late R.N.), who conducted many of the reconnaissances of 1874.

Administration.—Commissariat.—Mr. L. W. Herchmer (late 46th Regiment) was the Commissary of the Boundary Commission. The line of supplies which he had to maintain was, in 1873, 400 miles long, and, in 1874, it extended to 860 miles. Mr. Herchmer, in carrying out his work, made many hard journeys, with only one attendant, through the heart of the Indian country.

Medical Department.—Dr. T. J. W. Burgess, M.B., was surgeon to the Commission, and took part also in the botanical researches. He had under his charge during the progress of the work many serious cases of sickness and of severe injuries. Under his skilful treatment all his patients recovered. Dr. T. Milman, M.D., Surgeon's Assistant, was in medical charge of the parties in the field during most of the season of 1874.

Veterinary Surgeon.—Mr. W. G. Boswell, in addition to the usual duties of his appointment, was charged with the selection and purchase of the transport

animals, horses, oxen, and dogs, and of the waggons and carts composing the transport train of the Commission. Mr. Boswell, in carrying out the duties of his department, made extensive journeys through Canada, Minnesota, and Montana.

Natural History.—Mr. G. M. Dawson, geologist and naturalist to the Commission, examined the whole of the country traversed. Mr. Dawson, whose name is well-known in connection with these sciences, has published in Canada an exhaustive report on the geology and flora of the Boundary Line.

S. A.

APPENDIX.

Methods of Astronomical Observations.

Latitudes. The method of determining the latitude which was agreed to be pursued by the two Commissions was by observations of the differences of the zenith distances of north and south stars with the zenith telescope. This instrument is of American invention, and is exclusively adopted in the United States Coast Survey for the determination of latitudes; its use and theory are described in Vol. II. of Chauvenet's "Practical and Spherical Astronomy." The reasons which led to the adoption of this instrument for the work of the boundary survey were its portability, the simplicity both of the observations and of the subsequent computations, and the accuracy of the results. Table 9 of this Appendix gives the abstracts of the observations taken by the astronomers of the British Commission with this instrument, shewing the number of observations at each station, the number of days on which observations were taken, the total time occupied in completing each station, and the probable error of the results. Consideration of this table appears to show that the performances of the zenith telescope justify its selection for a work of the nature of the Boundary Commission.

The zenith telescopes used by the British Commission were three in number, two of them having been made by Würdemann, of Washington, U.S., in the year 1860, and one by Messrs. Troughton and Sims, of London, in 1872. They were 32 inches in focal length, with object glasses $2\frac{1}{2}$ inches in diameter. Each instrument was packed in two cases, which weighed, when full, 78 lbs. and 120 lbs. respectively.

The number of stars used by the British Commission for the latitude observations was 167 in all. The places of 66 of these were taken from the Nautical Almanack or from the Greenwich catalogue of the epoch 1864; 30 from the Greenwich catalogue, epoch 1860; 18 from the Greenwich catalogue, epoch 1850; and 53 from the British Association catalogue of the epoch of 1850.

The relative weights assigned to these catalogues were taken into account as follows*:—

Let ϵ δ be the probable error of the declinations in each catalogue, then the assumed values of ϵ^2 δ are:

* See Chauvenet, Vol. II., par. 233.

Greenwich catalogue of 1864, Nautical Almanack of current year, Greenwich catalogue of 1860, with 4 or more observations ..... 0·25

Greenwich catalogue of 1860, with less than 4 observations, Greenwich catalogue of 1850, with 6 or more observations ..... 0·40

Greenwich catalogue of 1850, with less than 6 observations ..... 0·50

British Association catalogue, with the additional modern authority of Argelander (2), Bessel, Brisbane, Henderson (2), Johnson (2), Pond, Rumker, Taylor (5), Wrottesley (2) ..... 0·70

British Association catalogue, on the authority of Bradley, Piazzi, and Taylor ..... 1· 0

British Association catalogue, on the authority of Groombridge alone.. 2· 3

When a star was found in more than one of the catalogues, the place assigned to it by the one having the most relative weight was used.

Deviation of the plumb-line.

The commonly received idea of a parallel of latitude is that of a circle on the earth's surface, formed by the intersection with it of a plane parallel to the plane of the equator; the 49th parallel of north latitude being therefore such a circle 49 degrees north of the equator. The only way of determining a first point on this or any parallel, is by finding a point whose zenith is the required number of degrees from the celestial equator. It is then assumed that the plumb-line from the point in question to its apparent zenith is truly vertical, and that the point on the ground is the same number of degrees from the terrestial equator that its apparent zenith is from the celestial one; but experience has shewn that this is not the case. The plumb-line can, strictly speaking, never be said to be truly vertical; local attraction, due to irregularities in the density and figure of the earth, pull it to one side or the other, and as there is no check on this, the absolute amount of the deviation at any one spot cannot be ascertained; but when a connection is made by actual survey between two points, situated at some distance apart, whose latitudes have been determined astronomically, the relative deviation of the plumb-line at the two spots is at once apparent. Deviations of this kind were almost constantly found to occur on the boundary line, so that the parallel passing through one station would not, if continued with the proper curvature, be identical with the parallel passing through the next station, and so on. Under these circumstances, it was a question for consideration whether the points determined astronomically to be in latitude 49 deg. N., should be simply joined, or whether a mean line parallel to the equator should be adopted.

On the British side, the opinion of the Astronomer Royal was obtained, and he recommended that in no case should there be any departure "in the smallest degree from the points determined by the actual use of astronomical instruments."

It was agreed between the British and United States' Commissioners that the astronomical determinations of each station should be adhered to, and the intermediate monuments and mounds between the stations were set up on lines having the same curvature as the 49th parallel of latitude, but not parallel to the equator. Had the boundary been marked throughout on a curve parallel

to the equator, not more than a very small portion of it would have had, astronomically, the latitude of 49 deg., and the work would have taken much longer to do.

The subject of deviation of the plumb-line is discussed in Article 86, Vol. I., of Chauvenet's work, before alluded to.

Table 10 of this Appendix gives a list of the station errors, showing how much each station is north or south of station No. 1.

Longitudes. The determination of the longitude at North Pembina, in November, 1872, was effected by comparing, by means of the electric telegraph, the local time with that of the observatory at Chicago, in the State of Illinois, United States, the length of the electric circuit being about 950 miles.

The local time at North Pembina was obtained by observing transits of standard nautical almanac stars with a portable transit instrument of 30 inches focal length, and an object glass of $2\frac{1}{2}$ inches in diameter. This instrument was constructed by Messrs. Troughton and Sims, in 1872. A box sidereal chronometer, by Sewill, was used on this occasion.

Time observations. The local time for the reduction of the zenith telescope observations was obtained by the use of the sextant, either by day or night, by the transits of zenith stars observed with the zenith telescope, or by transits observed with the portable transit. The latter instrument was, however, rarely mounted for this purpose; the other methods, though inferior, being sufficiently accurate.

Stands for large instruments. The stands upon which the zenith telescopes and the transit instruments were set up, were designed and constructed by Messrs. Troughton and Sims, of London. A drawing of the stand made for the portable transit instrument is given in Pl. IX. The dimensions of the metal top plates are adapted in plan to those of the iron stand, in whose pillars are the V shaped bearings in which the transit telescope revolves. This iron stand was of the kind shown in Pl. V. of Chauvenet, Vol. II. The wooden stand was so arranged that the weight fell nearly equally upon each foot, as is evident from the diagram plan. A small movement in azimuth was obtained by the V shaped grooves in the metal top plate being made moveable along slots in the plate itself.

For the zenith telescope the stands were somewhat smaller, but were similar in general construction. The instrument itself being a circular one, revolving on a central pillar, the weight was always equally distributed between the three foot screws which carried the pillar; the plan of the top plate of the wooden stand was, therefore, an equilateral triangle, and no movement in azimuth was of course required for the V shaped grooves.

The stands packed quite flat when they were taken to pieces, and were transported very easily; the weight of those for the portable transit being about 170 lbs. each, and of those for the zenith telescope about 140 lbs. It was at first supposed that logs of wood would be more suitable whenever they could be obtained; but this was found to be an error. What was required was not stability against a horizontal disturbing force, but against the tremors of the ground

produced by the necessary movements in the observatory tent. A post inserted in the ground has its sides in contact with the soil, and every footstep on the surface above is transmitted directly to them; the wooden stands were free from this effect, because their construction allowed of their being insulated as it were. This was done by digging a hole in the middle of the observatory tent, 2 feet square and 18 inches deep, the floor of the hole being levelled; the foot plates were then bedded carefully, each in its proper place, and the stand placed upon them. Any tremor from the surface of the soil was caught by the sides of the hole, or, if it did go as deep as its floor it could hardly affect the foot plates, as it would travel laterally underneath them. As a matter of fact, these stands were perfectly steady; they were used for $2\frac{1}{2}$ years, and carried over nearly 3,000 miles of country without suffering at all in serviceability. Two posts, each 8 feet long and 2 feet in diameter, would have weighed 1,600 lbs.; whereas the two stands only weighed 310 lbs., and being in parts they could, if necessary, have been carried wherever men could climb.

Observatory tents. A photograph of one of the observatory tents is given at the end of this paper. The tent is shewn as if it opened at the sides, and this was the original construction, but it was found that this was very inconvenient, the guys being much in the way of a person entering the tent at night, and there being a danger of his striking the instrument, which, when adjusted for observing a star of moderate elevation, pointed towards the doorway. The sides of the tent walls were therefore sewn up, and a door opened in one end. The roof opening was about $2\frac{1}{2}$ feet wide, and for this width, the roof when closed, was double, so as to keep out rain, each flap being buttoned or buckled down to the tops of the tent walls; when the roof was to be opened, the flaps were unbuttoned from the walls and were then pulled back by halyards passing through single blocks fastened to the tops of the tent poles. When the roof had to be closed, the flaps were pulled forward again by other halyards. There were four single blocks in all, and four halyards, two of each being outside the tent, and two inside.

Azimuths. The true direction of the connecting sight lines between the astronomical stations was obtained by one of three methods. 1st, by laying down a meridian with the portable transit instrument, and turning off an angle of 90° on a 7-inch transit theodolite; 2nd, by observation with the 7-inch theodolite of the horizontal angular distance at a known time between a circumpolar star at or near its elongation, and a fixed referring object on the earth's surface; 3rd, by the same operation as the last, using a circumpolar star, at any part of its course, as the point of reference.

The first of these methods was the most accurate, and was often used at the initial point of the connecting sight lines, where they were tangent to the parallel. It required more preparation than the other two methods, which were well adapted for checking the direction of the sight lines as they progressed.

Reconnaissance observations. The observations for latitude and longitude taken on the reconnaissances for fixing the approximate position of the astronomical stations and making a sketch map of the country, were taken with an 8-inch sex-

tant, the sun and the stars being both used. The 8-inch sextants, specially made by Messrs. Troughton and Sims for this expedition, were very good instruments of their class; with them a set of ten observations on a north and on a south object for latitude could always be depended upon within 100 yards. In cases where combined observations of objects on both sides of the zenith could not be obtained, the instrumental error of the sextant, which had been investigated, was applied. On the march the instruments were carried in a light spring waggon, and were always at hand for taking observations on the sun during the day at the hours best suited for finding the time and latitude.

For the longitudes, the local times were compared with that brought forward on four mean-time pocket chronometers, whose travelling rates were ascertained by taking them back to the starting point and observing for time there, after each reconnaissance. The resulting longitudes so obtained over long distances of 100 miles and upwards, served as a check on the survey. The reconnaissance sketches were made with the aid of a small prismatic compass.

Method of working practised by the astronomical parties.

The method of working generally practised by the astronomical parties was as follows:—On approaching the site selected for an astronomical station, usually at about 3 p.m., though sometimes much later, the first step was to select, for the observatory tent, an elevated spot from which an uninterrupted sight line could be obtained to a distance of about three-fourths of a mile, either due north or due south. The camp was then pitched at a short distance off, so that neither the north or south, nor the east or west lines from the observatory tent came within 100 yards of it.

The true time of the last astronomical station having been brought forward on a pocket mean time chronometer, or sometimes on an ordinary watch, the sidereal chronometer was started by it, allowance being made for the difference of longitude obtained from the reconnaissance sketches, and observations for time on the sun in the west were taken with a sextant for combination with equal altitudes the next morning. The zenith telescope was next mounted and adjusted, the direction of the meridian being obtained by observation of the transit, according to the time by account, of a circumpolar star as soon after sunset as practicable.

When darkness had set in, the latitude observations were commenced, a correction to the approximate time being soon obtained by taking transits of two zenith stars, and were continued throughout the night until dawn began to appear, the meridian being also altered if necessary during the course of the observations. The next morning equal altitudes were taken on the sextant corresponding to those obtained the previous evening, and the true chronometer error during the night being now known, the computers could set to work at once to reduce the latitude observations. A first value of the latitude of the zenith telescope was obtained before the afternoon, and a spot was selected the proper distance north or south of it, so as to be nearly on the 49th parallel, and, if possible, on the meridian of the instrument, from which point the sight line, tangent to the parallel, should be commenced; a view of nearly a mile due east or west, and also north or south being essential. The seven-inch theodolite was

mounted here, and as soon as Polaris could be found in the evening, an approximate meridian was established and a mark set up. The theodolite was then replaced by the portable transit instrument which was directed on this mark. All this could generally be done without interfering with the zenith telescope observations for latitude, which it was important to complete as soon as possible. These were continued on the second night without interruption; but, in the early part of the evening, and from time to time during the night, opportunities would occur for observing the transits of stars across the meridian of the transit instrument. The azimuth of this meridian was thus obtained within one or two seconds, or less, of arc, with much less trouble and fatigue to the eye than is involved in the use of a circular instrument. The reading of the fine divisions of a metal arc by artificial light is a great strain upon the sight, and is to be avoided whenever observations of more importance are to be made soon afterwards.

On the second day the computations were continued, and preparations were made for commencing the sight line to connect with the station to the west. For this purpose the seven-inch theodolite was placed over the spot where the portable transit had stood, and an angle of 90° was turned off to the west, giving a line approximately tangent to the parallel. A mark was set up on this line at a distance of about three-quarters of a mile, or more, if possible. The angle between this mark and that in the north was then read off on different parts of the arc, and in reversed positions of the face of the instrument, and the mean of these angular readings combined with the azimuth of the meridian, gave that of the sight line, which was generally a few seconds north or south of west. The sight line was now ready for prolonging westward, its deviation being left uncorrected, but being taken into account in computing the offsets to the parallel. On the third night the zenith telescope observations were continued and completed, subsidiary observations for correcting the constants of the instrument being taken if required.

On the third and fourth days the computations were finished and checked, and as soon as the final value of the latitude of the zenith telescope was obtained, the required measurement to the parallel was made, and the mound marking the station erected. During the fourth and fifth nights additional observations for azimuth were taken, as well as any additional ones required for the latitude. The sidereal time was obtained from day to day by equal altitudes of the sun, and also by observations of the transits of zenith stars at night; sextant observations of stars for this purpose were rarely resorted to, as they would have occupied time required for other purposes.

The time of completing a station, which, according to the above description, would be four days and five nights, was actually always more than this. Sometimes the first night could not be used for latitude observations, owing to the party having arrived too late at the station to make the necessary preparations, and one night out of three was generally cloudy or unfavourable to observation owing to thunderstorms or gales of wind. The average time necessary to complete one station was seven days during the summer months. In order to provide against delays from cloudy weather, it was always the object of the officer

in charge of the astronomical work to obtain as early as possible an approximate value of the latitude, within 20 or 30 feet, and an approximately true meridian; having obtained these, the tangent line could be commenced, and, in the event of cloudy weather setting in, could be prolonged for nine or ten miles, while, if the sky remained clear, the astronomical observations were carried on to completion. It may be remarked, that though clouds were not unfrequent, rain, except during thunderstorms, was unknown in the summer months.

When the astronomical station was completed, and the mound marking the parallel erected, the camp was shifted to some spot where water was to be had, about half way to the next astronomical station. During the march, the line was run with the seven-inch transit theodolite from the initial point, or from wherever it had been already taken to while the party was encamped at the station. From the new camping ground the line was continued as far as the next astronomical station, if possible; but if it was not within working distance, the camp was again shifted to an intermediate point. The prolonging of the tangent line was done with the seven-inch transit theodolite, each point in advance being determined by two observations with different faces of the instrument, to eliminate the residual collimation and errors of level adjustment. The time occupied in running an average distance of 20 miles of line was about four days, to which three more must be added for laying down the offsets from the tangent to the parallel, where the monuments or mounds were to be erected—viz., at intervals of three miles—and for constructing the mounds themselves.

The offsets from the tangent line to the parallel were computed as follows:—Each offset consisted of the following elements:—

C, a constant element, being the distance of the initial point of the tangent line north or south of 49°.

δ P, the distance measured along a meridian between the tangent line and the parallel, which interval increases as the square of the distance from their point of contact.

δ A, the correction to be applied to the tangent line for any small deviation from its true direction.

δ E, the proportional part of the station error due to the deviation of the plumb-line, and including also the probable errors of the astronomical observations at each station.

C, of course required no computation.

δ P, was computed according to the following formula:—

$$-d\,\mathrm{L} = \mathrm{K\,B}\cos \mathrm{Z} + \mathrm{K}^2\,\mathrm{C}\sin\ \mathrm{Z} + h^2\,\mathrm{D}$$

where d L = difference of latitude of the two points, K = length of side connecting them,

$$\mathrm{B} = \frac{1}{\mathrm{R}\ \mathrm{arc}\ 1''}$$

$$\mathrm{C} = \frac{\tan \mathrm{L}}{2\ \mathrm{N}\ \mathrm{R}\ \mathrm{arc}\ 1''}$$

$$D = \frac{\frac{3}{2} e^2 \sin L \cos L \text{ arc } 1''}{(1 - e^2 \sin^2 L)^{\frac{3}{2}}}.$$

$$h = K B \cos Z$$

$$R = \frac{a (1 - e^2)}{(1 - e^2 \sin^2 L)^{\frac{3}{2}}}$$

$$N = \frac{a}{(1 - e^2 \sin^2 L)^{\frac{1}{2}}}$$

A = equatorial radius of the earth = 6974127·31 yards; e = eccentricity = 0·081696830; Z = azimuth of tangent counting from south around by west, whence west = 90°; east = 270°.

This formula becomes in the present case — d L = K² C; or, taking offset in yards = d, distance along tangent line = D, log d = 2 log D + 2·915491.

If d and D are taken in chains, log d = 2 log D + 1·342423.

δ A = D sin A, A being the azimuthal error of the tangent line, D the distance from the initial point.

δ E = $\frac{D.E}{X}$, E being the station error, X the distance between the two stations.

It was convenient to call northern offsets +; southern offsets —; δ P was always +; the others might be either.

Azimuth observations were taken at or near the end of the line to verify its direction, and any small error which had accumulated in the process of laying it down was distributed over its whole length.

When this work was finished, the party started for their next station, about 80 miles further west, on arriving at which the same process was re-commenced.

Astronomical observations in cold weather.

In using astronomical instruments when the thermometer is down to zero of Fahrenheit or below it, the oil with which the internal bearings are lubricated is partially frozen, and the motions of revolution become very stiff. With theodolites the best remedy is to take them to pieces and carefully remove all the oil; the freedom of motion will then be restored. With the zenith telescope it is not advisable to do this, but the evil is less as the greater momentum of the parts overcomes the resistance offered by the congealing oil, and force can be used with less danger to the correctness of the observation, which is not one of azimuth. Precautions have to be taken, however, against the freezing of the lamps, and of the oil in the works of the chronometers. The best way of doing this is to erect a small tent sufficiently near to the observatory to be within reach of the voice at its ordinary pitch; in this tent, which is warmed with a small stove, are the assistant with the chronometer and note-book, and another person whose business it is to keep always ready a spare lamp to replace the one at the instrument as soon as its oil freezes. The observer in the large tent has thus, during the intervals of work, a ready source of warmth to which he can resort, and he is not troubled with considerations as to the welfare of his assistants. By using these precautions, observations were

frequently taken during the winter of 1872, throughout a great part of the night, when the thermometer was 30° below zero of Fahrenheit, without any one suffering serious inconvenience.

The instrument on these occasions was a 7-inch theodolite in the open air, the tent with the stove being placed near it. The plan of using merely an open fire, however large, was liable to failure, as it afforded little or no protection to the chronometer, of which the rate, when it is exposed to severe cold, will vary seriously. For accurate time-observations when records of fractions of seconds are required, it would be difficult, however, to separate the observer and the chronometer without using an electric chronograph.

Tables. Tables were prepared for facilitating the computations. These were:—

I. Table of factors for collimation, level, and azimuth errors of a transit instrument, computed for latitude 49° N, for the visible heavens. The same for the five circumpolar stars for every 10″ of change of N.P.D. during the season.

II. Azimuths of Polaris (at a mean declination) for hour angles, from 0 to 12 hours, computed for every 10 minutes for lat. 49° N. This table was used for laying down an approximate meridian.

III. Differential table of refractions for zenith telescope observations. See Chauvenet, Vol. II., chapter on zenith telescope.

IV. Values of $\frac{\sin^2 \frac{1}{2} t}{2 \sin 1''} \sin 2\delta$ up to 1 minute of time.

V. Values of $\frac{2 \sin^2 \frac{1}{2} t}{\sin 1''}$ up to 5 minutes of time.

VI. Values of $\frac{\cos \varphi \sin \text{N.P.D.}}{\sin 2 \text{ D}}$ for lat. 49° N, from N.P.D. + 6° to N.P.D. + 76°.

VII. Values of $37{\cdot}5 \sin^2 1'' \times t^3$ up to 30 minutes of time. This and the three preceding tables were used in connection with the zenith telescope observations.

IX. Azimuths of eight circumpolar stars at elongation, for every tenth day during the season, for latitude 49°, and for every mile north of it up to 6 miles.

X. Approximate time of the above elongations after noon on any day of the year.

This table was formed by computing the sidereal interval between the upper transit and elongations of each star, and adding or subtracting this interval to or from its R.A. Turning the result into mean time, and adding to it the mean time of the preceding sidereal noon (taken from the Nautical Almanac), the sum was the mean time of the elongation, *i.e.*, it was the time by an ordinary watch. The object of this table was to enable any one who was not possessed of the means of obtaining the true local time to know, without computation, when to be ready to observe a circumpolar star at elongation. Such a person could always set his watch with sufficient accuracy by the rising or setting of the sun.

Forms. Printed forms were prepared in England for recording the astronomical observations; the computations were much facilitated by this.

Star places.

The apparent places in declination and right ascension of the stars used in the zenith telescope observations were computed beforehand for every tenth day throughout the working season; from these the places for any night were found by interpolating to first differences.

General remarks on the use of the zenith telescope.

An instrument of the size of the zenith telescope may have its focussing tube moveable by a large mill-headed screw, or it may be arranged so that, when once focussed, it is held by capstan-headed screws. If the latter plan be adopted, there will be no danger of the length of the focus being altered by accident, but occasionally it will be found that the instrument is slightly out of focus, owing to change of temperature. A good plan is to focus the instrument on a cold night, and again on a warm one, noting the temperatures, and to observe in each case for the value of the revolutions of the micrometer. Two different values will be obtained, that at the lowest temperature being the highest. A table may then be formed of the micrometer values for each degree of temperature intermediate between those at which the observations were taken, the change in the values being made proportional to that of the temperatures. If the instrument has a mill-headed focussing screw, the observer can now adjust for distinct vision every night, or two or three times in a night, noting always the temperature, and using in the computations the corresponding micrometer values.

As with the zenith telescope, the accuracy of the observations depends greatly upon the true value of the micrometer revolutions, it is advisable to take the additional precaution of equating the north and south zenith distances of the stars on which the final result depends.

The opening of the roof in the tent or house in which the observations are taken, should not be too narrow. On one occasion, owing to a desire to use the same tent opening for two large instruments, the line of sight from the zenith telescope passed within 3 inches of the canvas on one side. It was found that the observations gave very bad results, and the arrangement had to be altered. A similar case is recorded in the preface to the Greenwich catalogue of 1860 as having occurred there. It appears that the currents of warm air passing round the edge of such an opening produce irregular refractions, and the line of sight should have 12 inches of clear space on each side of it.

Observations during twilight are not reliable. There is always a temptation to take them, especially immediately after sunset, because the night is lengthened by so much; but it is best not to do so, because, in the first place, the focus of a large instrument rapidly changes at this time owing to the fall of temperature, and does not attain a constant state till darkness has quite set in; in the second place, owing to the sun illuminating the upper portion of the atmosphere only, there is a lateral irregularity of refraction, which cannot be taken into account, but which makes itself felt in the results. This was especially noticed in azimuth observations.

The maker of a zenith telescope should construct the striding level of adequate size; it should be as long as possible consistent with the dimensions of the instrument; if it is too short it gives the observer a great deal of trouble.

Before taking a series of observations with the zenith telescope, a programme should be ruled out in the note-book; this programme should contain—

1. The time at which each star will come into the field of view.
2. The setting on the vertical arc.
3. The zenith distance of the star.
4. The micrometer division near which the star will appear.
5. The B.A.C. number of the star.
6. Whether the star is north or south of the zenith.
7. A place where the actual time of observation will be entered.
8. A place where the reading of the micrometer will be entered.
9. A place for the readings of the level.
10. A column for remarks.

There will thus be ten columns, and the programme should include every star that is expected to be observed during the night; then, if only one pair is obtained, a fresh programme should be ruled out for the next night, otherwise there will be confusion.

By following this plan exactly, much trouble will be saved both to the observer and the computer.

Portable transits. Portable transit instruments should have two lamp stands, so that when the instrument is reversed, it may not be necessary to change the position of the stand, in doing which there is much danger of altering the azimuth.

Transit theodolites. Transit theodolites which are to be used for taking azimuth observations at night, should be so constructed that they will swing over when the diagonal eye-piece is being used.

The verniers should not be underneath the ends of the axis of the telescope, because it will then be nearly impossible to read that one over which is the lamp which illuminates the field of view. An illuminating lamp should not fit the cup of its stand too accurately, because, when it gets hot, it expands, and thus cannot be got out of its stand if required. All astronomical instruments should have the illumination of their fields of view examined before they are removed from the maker's hands. This seems to be a small detail, but, in reality, bad illumination is a serious defect, and difficult to remedy.

Computers. A computer should be a neat and quick writer; he can be taught everything else as the work proceeds.

List of equipment, &c. Some lists of equipment are given in the tables at the end of this paper; some others, not necessary to put in detail, are

Medical Equipment.—This consisted of two complete sets of Messrs. Savory and Moore's medical field panniers, Nos. 1 and 2.

Photographic Equipment.—This consisted of two sets of field equipment, selected by Captain Abney, R.E.

Signalling Equipment.—This consisted of 6 of Walker's lime lights, with the necessary stores.

Norton's Tube Wells.—Two pumps complete.

Chemical Equipment.—Blow pipe, test tubes, reagents, &c., for examining minerals.

TABLE I.

Return of the Non-Commissioned Officers and Men of the Royal Engineers serving with the North American Boundary Commission, showing their Regimental Rank and Trades.

Nos.	Rank.	Trades.	Abstract of Trades.
1	Sergt. Major.	Mason	1 Baker
1	Qr. Mr. Sergt.	Clerk	2 Bricklayers
2	Sergeants	Clerk	5 Carpenters
		Surveyor	6 Clerks
4	Corporals	Clerk	1 Mason
		Smith	4 Photographers
		Smith	1 Saddler
		Surveyor & Draughtsman	1 Sawyer
4	2nd Corporals	Smith	2 Shoemakers
		Saddler	6 Smiths
		Clerk	8 Surveyors from Ordnance Survey
		Clerk	2 Surveyors from Chatham
5	Lce. Corporals	Bricklayer	1 Tailor
		Surveyor	3 Tinsmiths
		Baker	1 Wheelwright
		Surveyor	44
		Surveyor & Draughtsman	
27	Sappers	1 Bricklayer	Amongst the four photographers there were 1 millwright, 1 wheelwright, 1 carpenter, and 1 surveyor; 2 shoemakers were also surveyors.
		5 Carpenters	
		1 Clerk	
		4 Photographers	
		2 Shoemakers & Surveyors	
		3 Smiths	Of the above, 1 clerk, 1 shoemaker and surveyor, and 1 tinsmith became casualties during the first six months, and were replaced by 1 harnessmaker, 1 shoemaker and photographer, and 1 tailor.
		5 Surveyors	
		1 Tailor	
		3 Tinsmiths	
		2 Wheelwrights	
44			

REMARKS.—The men having two trades were employed at either as required; one tailor not being found sufficient, another was applied for when a casualty occurred.

One of the non-commissioned officers was a certified instructor in military signalling, including the use of the lime-light apparatus.

TABLE II.

Return of the Clothing and Equipment of the Non-Commissioned Officers and Men of the Royal Engineers on duty with the North American Boundary Commission.

Nos.	Articles.	Remarks.
1	Jacket, Norfolk, blue tweed...	
1	Jersey, woollen	
1 pair	Trowsers, blue tweed.....	Each non-commissioned officer and Sapper took with him also the regimental clothing which he had in wear at the time, except his busby and knapsack.
1 „	Trowsers, serge	
1	Cap, Glengarry	
1	Cap, blue worsted	
1	Mackintosh overcoat.....	
1 pair	Waterproof leggings	
1 „	Boots, knee	
1 „	Boots, ankle.....	
1	Fur cap	
1	Comforter	
1	Black neck-tie	
1	Waterproof sheet	
1 pair	Blankets, grey, field service ...	
1	Sea-kit bag	
1	Lancaster rifle, Snider	
1	Sword bayonet for ditto	
1	Revolver, Dean's.....	
40 rounds	Snider ammunition	
24 rounds	Revolver ditto	
1	Skin jacket	Winter clothing provided at Red River.
1 pair	Skin Trowsers.....	
1 „	Skin mits.....	
1 „	Woollen mits	Worn inside the skin mits.
1	Great coat with hood, (Hudson's Bay pattern)	
1	Buffalo robe	
3 pairs	Blankets	
	Mocassins as required	The work in the woods and swamps during the winter was very destructive of mocassins, a pair of which would sometimes scarcely last a fortnight.
	Snow shoes	The snow shoes were apt to get broken in walking through bush and windfall; on an average, two pairs were used by each person during three months of the winter of 1872-73. N.B.—The clothing, as it wore out, was replaced by articles procured from Canada, which were fitted by the tailors.

TABLE III.

Detail of the parties of the North American Boundary Commission at work in the field during the Summer of 1873 and 1874.

PERSONNEL.	Officers.	Staff and N.C.Os.	Men.	Horses.	Ponies.	Oxen.	Vehicles.	Tents.
Commissioner's Party.								
Commissioner	1	..	..	1	..	..	..	..
Secretary, Captain Ward, R.E.	1	..	..	1	..	..	..	..
Clerks	..	1	..	..	..	..	..	..
Photographers	..	..	4	..	..	..	..	..
Teamsters	..	..	9	..	..	..	..	..
Cooks	..	..	1	..	..	..	..	..
Servants	..	..	2	..	..	..	..	..
Storeman	..	..	1	..	..	..	..	..
Whitewater waggons	..	..	..	4	..	..	2	..
Red River carts	..	..	..	..	5	..	3	..
Spring waggons	..	..	..	2	..	..	2	..
Bell tents	..	..	..	..	..	..	..	1
H. B. Cy. „	..	..	..	..	..	..	..	7
Lumberers „	..	..	..	..	..	..	..	2
Chief Astronomer's Party.								
Captain Anderson, R.E.	1	..	..	1	..	..	..	..
Commander of Scouts	1	..	..	1	..	..	..	..
Leaders of „	..	4	..	4	..	..	..	..
Scouts	..	..	26	..	26	..	..	..
Teamsters	..	..	4	..	..	..	..	..
Servants	..	..	1	..	..	..	..	..
Whitewater waggons	..	..	..	6	..	..	3	..
Spring waggons	..	..	..	2	..	..	2	..
Water cart	..	..	..	1	..	..	1	..
Bell tents	..	..	..	..	..	..	..	3
1*st Astronomical Party.*								
Capt. Featherstonhaugh, R.E.	1	..	..	1	..	..	..	..
Mr. W. F. King	1	..	..	..	..	..	..	..
Mr. W. A. Ashe	1	..	..	..	..	..	..	..
Senior Non.-Com. Officer	..	1	..	..	..	..	..	..
Royal Engineers, rank and file	..	..	7	..	..	..	..	..
Storeman	..	..	1	..	..	..	..	..
Teamsters	..	..	7	..	..	..	..	..
Cooks	..	..	2	..	..	..	..	..
Servants	..	..	2	..	..	..	..	..
Axemen in Turtle Mountain	..	..	7	..	..	..	..	..
Whitewater waggons	..	..	..	10	..	..	5	..
Spring waggons	..	..	..	2	..	..	2	..
Water carts	..	..	..	2	..	..	2	..
Bell tents	..	..	..	..	..	..	..	3
H. B. Cy. „	..	..	..	..	..	..	..	9
Lumberers „	..	..	..	..	..	..	..	3

TABLE III.—Continued.

PERSONNEL.	Officers.	Staff and N.C.Os.	Men.	Horses.	Ponies.	Oxen.	Vehicles.	Tents.
2nd Astronomical Party.								
Lieutenant Galwey, R.E.	1	..	..	1	..	..	..	..
Mr. G. Burpee	1	..	..	..	..	..	..	..
Mr. G. C. Coster	1	..	..	..	..	..	..	..
Computers	..	1	..	..	..	..	..	..
Senior Non.-Com. Officer	..	1	..	..	..	..	..	..
Royal Engineers, rank and file	..	..	7	..	..	..	..	..
Storeman	..	..	1	..	..	..	..	..
Teamsters	..	..	6	..	..	..	..	..
Cooks	..	..	2	..	..	..	..	..
Servants	..	..	2	..	..	..	..	..
Whitewater waggons	..	..	..	10	..	..	5	..
Spring waggons	..	..	..	2	..	..	2	..
Water carts	..	..	..	2	..	..	2	..
Bell tents	..	..	..	..	..	..	..	3
H. B. Cy. „	..	..	..	..	..	..	..	9
Lumberers „	..	..	..	..	..	..	..	3
1st Surveying Party.								
Colonel Forrest	1	..	..	1	..	..	..	..
Topographers	..	1	1	..	2	..	..	..
Surveyors, Chainmen, &c.	..	..	6	..	..	..	..	..
Storeman	..	..	1	..	..	..	..	..
Teamsters	..	..	2	..	..	..	..	..
Cooks	..	..	1	..	..	..	..	..
Servant	..	..	1	..	..	..	..	..
Spring waggons	..	..	..	1	..	..	1	..
Red River carts	..	..	..	..	3	..	3	..
Water carts	..	..	..	1	..	..	1	..
Bell tents	..	..	..	..	..	..	..	1
H. B. Cy. „	..	..	..	..	..	..	..	3
2nd Surveying Party.								
Mr. A. L. Russell	1	..	..	1	..	..	..	..
Surveyor's assistants	..	1	..	..	1	..	..	..
Topographer	..	1	..	..	1	..	..	..
Surveyors, chainmen, axemen, &c.	..	..	10	..	..	..	..	..
Storeman	..	..	1	..	..	..	..	..
Teamsters	..	..	2	..	..	..	..	..
Cook	..	..	1	..	..	..	..	..
Servant	..	..	1	..	..	..	..	..
Spring waggon	..	..	..	1	..	..	1	..
Red River carts	..	..	..	..	3	..	3	..
Water carts	..	..	..	1	..	..	1	..
Bell tents	..	..	..	..	..	..	..	1
H. B. Cy. „	..	..	..	..	..	..	..	3
3rd Surveying Party.								
Sergeant Kay, R.E.	..	1	..	1	..	..	..	..
Surveyors, R.E.	..	..	7	..	..	..	..	..

TABLE III.—Continued.

Personnel.	Officers.	Staff and N.C.Os.	Men.	Horses.	Ponies.	Oxen.	Vehicles.	Tents.
3rd Surveying Party continued.								
Teamsters	..	..	2	..	..	..	..	..
Cook and storeman	..	..	2	..	..	..	..	..
Axemen	..	..	2	..	..	..	..	..
Spring waggon	..	..	..	1	..	..	1	..
Red River carts	..	..	..	..	4	..	4	..
Water carts	..	..	..	1	..	..	1	..
Bell tents	..	..	..	..	..	..	..	1
H. B. Cy. „	..	..	..	..	..	..	..	3
Special Survey Party.								
Mr. East	1	..	..	..	..	..	..	..
Topographer	..	1	..	..	..	..	..	..
Chainmen, axemen, &c.	..	..	8	..	..	..	..	..
Storeman	..	..	1	..	..	..	..	..
Cook	..	..	1	..	..	..	..	..
Bell tents	..	..	..	..	..	..	..	1
H. B. Cy. „	..	..	..	..	..	..	..	3
Surgeons' Party.								
Dr. T. J. W. Burgess, M.B.	1	..	..	1	..	..	..	..
Dr. Thos. Millman, M.D.	1	..	..	1	..	..	..	..
Teamsters	..	..	5	..	..	..	..	..
Servant	..	..	1	..	..	..	..	..
Spring waggons	..	..	..	2	..	..	2	..
Spring carts	..	..	..	2	..	..	2	..
Ambulances	..	..	..	4	..	..	2	..
Water carts	..	..	..	2	..	..	2	..
Bell tents	..	..	..	..	..	..	..	1
H. B. Cy. „	..	..	..	..	..	..	..	2
Lumberers „	..	..	..	..	..	..	..	3
This party was equipped so that if required, it could be divided into two sections, each complete in itself; each ambulance had a complete set of panniers.								
Geologist's Party.								
Mr. G. M. Dawson	1	..	..	1	..	..	..	..
Assistant	..	..	1	..	..	..	..	..
Teamsters	..	..	2	..	..	..	..	..
Servant	..	..	1	..	..	..	..	..
Red River carts	..	..	..	..	3	..	3	..
Bell tents	..	..	..	..	..	..	..	1
H. B. Cy. „	..	..	..	..	..	..	..	1
Lumberers „	..	..	..	..	..	..	..	1
Commissariat Trains.								
Commissary, Mr. W. Herchmer	1	..	..	1	..	..	..	..
Quartermaster Sergeant	..	1	..	..	..	..	..	..

TABLE III.—Continued.

PERSONNEL.	Officers.	Staff and N.C.Os.	Men.	Horses.	Ponies.	Oxen.	Vehicles.	Tents.
Commissariat Trains continued.								
Teamsters	..	..	44	..	..	...	...	...
Servant	..	..	1	..	..	...	...	...
Whitewater waggons	..	..	..	26	..	48	36	...
Red River carts	..	..	..	..	14	...	14	...
Bell tents	..	..	..	..	..	...	...	1
H. B. Cy. "	..	..	..	..	..	...	...	7
Lumberers "	..	..	..	..	..	...	...	12
Water carts	..	..	..	1	..	...	1	...
Veterinary Surgeon's Party.								
Vet. Surg. Mr. W. G. Boswell.	1	..	..	1	..	...	...	...
Waggon master	..	1	..	...	..	...	...	...
Teamsters	..	..	2	...	..	...	...	...
Servant	..	..	1	...	..	...	...	...
Whitewater waggons	..	..	..	2	..	...	1	...
Red River carts	..	..	..	..	2	...	2	...
Bell tents	..	..	..	...	..	...	...	1
H. B. Cy. "	..	..	..	...	..	...	...	2
Lumberers "	..	..	..	...	..	...	...	2
Depôts.								
Depôt keepers	..	7	..	...	..	...	...	...
Artificers, Royal Engineers	..	1	8	...	..	...	...	...
Axemen and labourers	..	..	18	...	..	...	...	...
Haymakers	..	..	4	...	..	...	...	...
(1873) Total	18	23	230	100	59	48	112	93
(1874) Total	16	22	219	114	55	210	179	66

N.B.—In 1874 there was only one survey party, which was under Lieutenant Rowe, R.E. The increase in the numbers of oxen and waggons was on account of the long distance (800 miles) over which supplies had to be carried. The decrease in the number of tents was because bell tents were almost exclusively used, instead of the H. B. Company pattern.

TABLE IV.

ASTRONOMICAL INSTRUMENTS.

No.	ARTICLES.	No.	ARTICLES.
3	Zenith telescopes	6	Large stands for astronomical instruments
2	Transits, 30″ with 2½″ apertures on portable iron stands	1	Alt-azimuth, with vertical circle, 14″ in diameter
1	Transit	6	Chronometers, box, regulated to sidereal time
1	Transit, small	12	Chronometers, pocket, regulated to mean solar time
6	Sextants, 8 inch	3	Observing tents
6	Artificial horizons, mercurial, with roofs		
6	Iron bottles containing mercury		
6 Sets	Spare glasses for roofs of artificial horizons		

TABLE V.

SURVEYING INSTRUMENTS.

No.	ARTICLES.	No.	ARTICLES.
18	Prismatic compasses in sling cases	3	Transit theodolites, 7″
36	Pocket compasses, magnetic	1	,, ,, 6″
5	Abney's Levels	4	,, ,, 5″
2	Pocket Sextants, best	4	Everest's ,, 4″
6	Sketching cases, large	6	Azimuth compasses in boxes
6	,, ,, small	6	Telescopes, small, in sling cases
1	Binocular glass, with hinge	4	Watches, Russell's
5	Binocular glasses in sling cases	1	Chain, steel, standard in box
12	66 feet chains and arrows	6	Flags, black, large
6	Tapes, 100 feet	6	,, ,, small
6	,, 50 feet	6	,, white, large
6	Portable levels in wood frames	6	,, ,, small
6	Telescopes, naval, with caps and slings		

TABLE VI.

MAGNETIC INSTRUMENTS.

No.	ARTICLES.	No.	ARTICLES.
1	Vibration apparatus	1	Azimuth compass
1	Portable declinometer	1	Dip circle and tripod stand

TABLE VII.

METEOROLOGICAL INSTRUMENTS.

No.	ARTICLES.	No.	ARTICLES.
4	Standard barometers with brass tripod stands, fitted in leather travelling cases	3	Regnault's hygrometers, with one thermometer to each
		3	Glaisher's rain gauges
2	Mountain barometers with brass tripod stands, fitted in leather travelling cases	2	Metal aspirator jars, with taps and India-rubber tubing
		6	Maximum thermometers
2	Brackets with bronzed fittings for two barometers	6	Minimum ditto
		2	Long ditto, ranging to 150° below zero
6	Earth thermometers in brass frames, with moveable cover and fitting to enable each to be inserted 1, 2, or 3 inches in the earth	2	Solar radiation in vacuum thermometers
		2	Anemometers, Robinson's
		8	Extra glasses for water cups of hygrometers
3	Earth thermometers in brass frames for use at depth of 3 feet	6 Pairs	Gold band aneroid barometers, selected, R.E. pattern, the pairs adjusted to shew the same readings
2	Standard wet and dry bulb hygrometers		
6	Common ditto		

TABLE VIII.

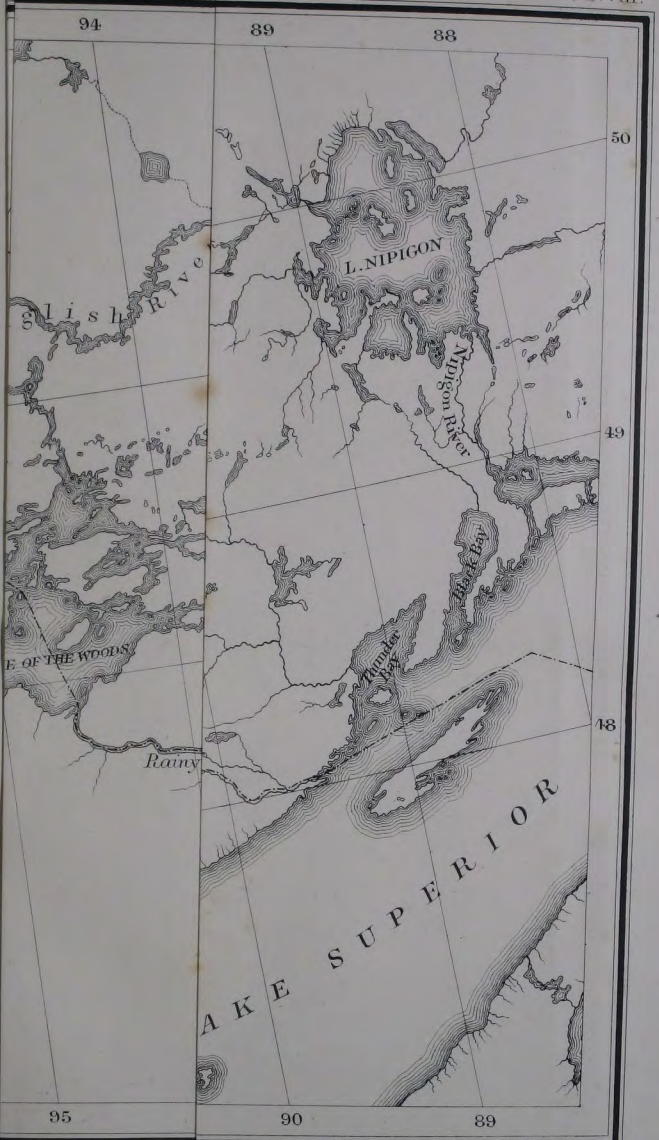
Scientific Books and Forms.

No.	Articles.	No.	Articles.
6	Nautical Almanacs, 1872	1	Verification of La Caille's arc of the meridian
6	" " 1873		
6	" " 1874	1	Longitude of Valentia—Astronomer Royal
6	" " 1875		
1	B.A.C. Catalogue, 1850	1	Magnetism—Airy
3	Greenwich Catalogues, 1850	3	Tables of barometric corrections to 32 deg. Fahr.
3	" " 1860		
3	" " 1864	400	Forms No. 1 for transits of stars
2	Bessel's Refraction Tables, modified and expanded, being the appendix to the Greenwich Observations of 1853	800	Forms No. 2. Observations for latitude with the zenith telescope
		500	Forms No. 3. Observations for latitude with the alt-azimuth
6	Geodetical Tables, Ordnance Trigonometrical Tables	100	Forms No. 4. Observations for latitude with the transit instrument placed in the prime vertical
2	Logarithms of Sines and Cosines of Time		
3	Tables of Logarithms—Babbage		
3	" " —Dupuis	100	Forms No. 5. Errors and rates of chronometers
12	" " —5 figure		
3	Practical and Spherical Astronomy—Chauvenet, 2 vols.	200	Forms No. 6. Comparisons of chronometers with standard
6	Practical Astronomy—Loomis	200	Forms No. 7. Longitude by transfer of chronometers
2	Plane and Spherical Trigonometry—Chauvenet	200	Forms No. 8. Longitude by moon-culminating stars
3	Practice of Navigation, Raper		
7	Shadwell on chromometers	½ ream	Apparent places of stars, for zenith telescope observations
3	Shortrede's tables		
5	Admiralty Manual of scientific enquiry	200	Form A. Latitude by meridian observation of sun or star
3	Meteorology—Kaemtz	200	Form B. Time by equal altitudes of sun or star
3	" Practical—Drew		
3	" —Herschel	500	Form C. Time by altitudes of east and west stars
3	" —Buchanan		
3	Outlines of Astronomy—Herschel	500	Form D. Latitude by circum-meridian altitudes of sun or star, and by altitudes of Polaris at any time
3	Popular Astronomy—Airy		
3	Heather on mathematical instruments		
3	Hygometrical tables		

TABLE IX.

Abstract of the Observations for Latitude, taken with the zenith telescope, by the Officers of the British North American Boundary Commission, 1872-3-4.

No. of Station.	Situation.	Number of Observations	No. of days of Observation.	No. of days at station.	Probable error of result.	Remarks.
					Feet	
	North West Angle of the Lake of the Woods....	66	5	23	13	Winter.
1	Buffalo Point	94	5	10	8·88	Autumn.
2	Pine River	66	4	17	11	Winter.
3	West Roseau	78	3	6	10·23	Winter.
4	Pembina	77	7	16	9·42	Autumn.
5	Pointe de Michel	74	3	7	14·18	
6	Pembina Mountain, E...	93	4	10	10· 5	
9	.....	92	4	6	9·02	
10	Turtle Mountain, E.....	86	4	5½	10·45	
12	Souris River, 1st Crossing	90	4	11	7·09	
14	" " 2nd "	97	3	8	11·14	
16	Short Creek	98	4	8	10·84	
18	Le Grand Coteau.....	91	3	5½	7·09	
20	Big Muddy	70	5	6½	9· 4	
22	West Poplar River	78	5	9	9·83	
24	Little Rocky Creek	83	8	12	8·16	Weather cloudy.
26	Cottonwood Coulé	87	5	9	7·70	Ditto.
28	.....	66	3	6	5·85	
30	West Fork, Milk River ..	85	3	5	6·48	
32	Milk River, West Bank..	65	3	6	6·84	
34	West Butte	85	3	5	5·26	
36	South Branch of Milk River	66	3	5½	6·77	
38	Chief Mountain	79	3	6	5·16	
39	Belly River	76	3	5½	9· 3	



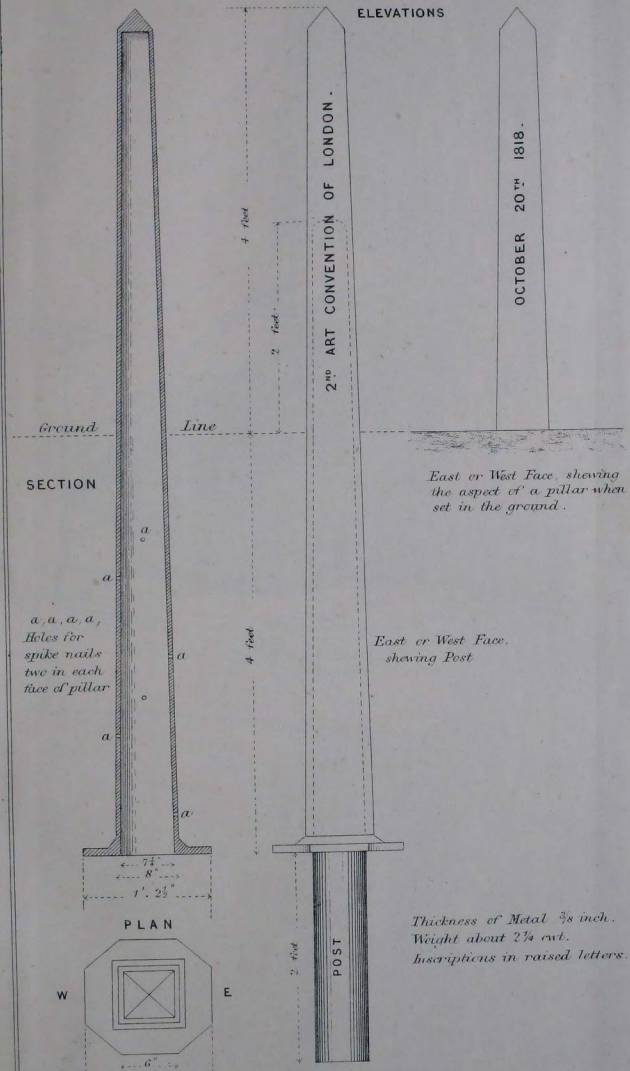
THOS KELL, LITH 40, KING STREET, COVENT GARDEN.

PILLAR MONUMENTS
CAST IRON.

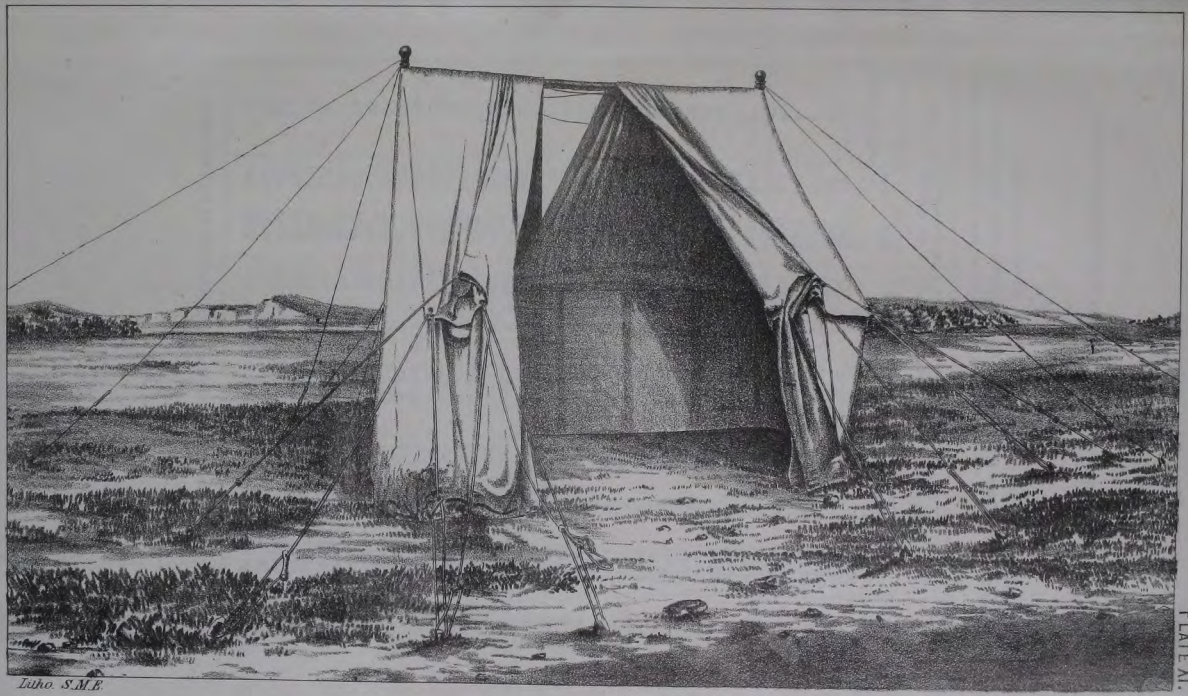
Pl. X.

Scale. ½0.

ELEVATIONS



THOS KELL, LITH 40 KING STREET COVENT GARDEN.



Litho. S.M.E.

PLATE XI.

TENT — 10 ft. Square in plan, Poles 10 ft. high, Wall 4 ft. 6 in. high.

TABLE X.

List of the Astronomical Stations, shewing their distances from Station No. 1, their longitudes and their positions North or South of a small circle passing through Station No. 1, and parallel to the Equator.

Nos.	Distance from Station No. 1		Distances N. or S.	By whom observed.	Longitudes West of Greenwich.		
	Miles.	Links.	Feet.		deg.	min.	sec.
N. W. Angle.				British.	95	8	56·7
1	0	0	0	B. and U. S.	95	16	55·26
2	31	7205	388 N	British,	95	59	00·99
3	68	1283	470·2 N	do.	96	46	51·85
4	88	4936	556·1 N	B. and U. S.	97	13	51·50
5	108	5962	588·4 N	do.	97	40	25·16
6	124	0002	533·3 N	do.	98	00	32·96
7	135	6307	459·5 N	U. S.	98	16	06·29
8	165	1305	376·7 N	do.	98	54	52·06
9	183	3911	213·4 N	British.	99	19	02·36
10	203	7729	54·15 N	do.	99	46	04·26
11	238	1510	154·91 N	U. S.	100	31	13·86
12	258	744	240·21 N	British.	100	57	29·76
13	281	1973	203·31 N	U. S.	101	28	02·96
14	303	7150	40·01 N	British.	101	57	56·06
15	325	3846	7·85 N	U. S.	102	26	25·16
16	343	2892	183·45 N	British.	102	50	00·86
17	359	3254	203·25 N	U. S.	103	11	11·26
18	377	2977	138·85 N	British.	103	34	53·66
19	400	4925	414·06 N	U. S.	104	05	33·96
20	426	5035	40·36 N	British.	104	39	53·56
21	451	1841	152·49 N	U. S.	105	12	21·36
22	473	3454	334·9 N	British.	105	41	39·16
23	496	6906	157·29 N	U. S.	106	12	34·36
24	522	4742	390·7 N	British.	106	46	31·46
25	550	6740	436·9 N	U. S.	107	23	48·16
26	567	3881	543·6 N	British.	107	45	45·86
27	588	1931	540·9 N	U. S.	108	13	09·26
28	615	3202	397·1 N	British.	108	48	59·56
29	642	218	836 N	U. S.	109	24	7·76
30	655	2357	669·3 N	British.	109	41	38·16
31	677	281	446 N	U. S.	110	10	19·46
32	702	3023	166·6 N	British.	110	43	46·06
33	723	383	304·3 S	U. S.	111	11	2·56
34	739	5780	571·2 S	British.	111	33	02·66
35	760	3160	167·7 N	U. S.	112	00	19·46
36	785	279	182·7 N	British.	112	32	50·36
37	804	3361	116·7 N	U. S.	112	58	25·16
38	825	6138	112·5 S	British.	113	26	35·26
39	836	3385	383·5 S	British.	113	40	38·96
40	846	240	10·6 S	U. S.	113	53	19·66
41	853	2529	134·6 N	B. and U. S.	114	02	56·46

NOTE.—Station 41 was observed by the Joint Commission of 1861.

PAPER IX.

THE RECENT TRANSIT OF VENUS.

By Captain ABNEY, R.E.

It may be of interest to cast a retrospective glance on the late Transit of Venus, recording, as far as is at present known, the results obtained, and also to leave on record the names and stations of the observers and their assistants, as so many of the corps were engaged on the work.

Some eighteen months before the actual transit took place, the Astronomer Royal commenced his selection of observers to represent the English expeditions, and it is no secret that he endeavoured to secure the services of a far larger number of Artillery and Engineer officers than he was finally able to send out. As it was, the vacancies almost at the last minute were filled up by civilians who had had some previous training in astronomy. As will be seen by the annexed table, besides two Artillery officers, (both of the Marine branch) three Engineer officers were engaged in the expeditions, and the photographic assistants, to the number of fifteen, were wholly supplied by the corps. To Chatham the Astronomer Royal also looked for giving the necessary instruction in photography, and at one time in our photographic school we had 18 men training for this special work, besides 5 officers and civilians at the observatory. Fortunately Lieut. R. Darwin, R E., threw himself into the photographic work, and took a great deal of the manipulative instruction into his hands, aiding most essentially in the matters of photo-heliograph drill, and amending the processes to be employed. At Greenwich a certain amount of hesitation was felt in adopting a dry plate process at first, as all recent eclipse work, and the sun diagrams taken at Kew, and subsequently at the Royal Observatory, had been taken by the wet method. It was only after we had successfully worked out a dry plate process, known as the "albumenbeer" process, that it was finally determined to adopt this method. Its advantages consist in an absolute impossibility for the films to shrink during manipulation (a matter of the highest importance where exact measurements have to be taken), whilst at the same time the plates could be prepared weeks or months in advance; in fact in Egypt, during the transit, we exposed plates which had been prepared at home months before. The dry plate process employed is given in the ap-

pendix, and I believe it to be thoroughly reliable for all classes of work. The training of the Sappers commenced on the 1st January, 1874, and with the aid of the photo-heliograph lent by Sir G. Airy for the purposes of instruction, they were *au fait* at the process about May, soon after which the first expedition started for Kerguelin's land. During most of that time Lieut. Darwin was able at intervals to come to Chatham, keeping up his work at the Observatory at Greenwich at the same time.

I need not enter into the details of the instruments employed at each station. Suffice it to say that each party was furnished with an altazimuth, a transit instrument, and equatorially mounted telescopes (none less than $4\frac{1}{2}$-inch) for each observer. The amount of forethought necessarily expended on the supplies and comforts for each expedition was immense, and none laboured so hard as Captain Tupman, R.M.A. He had been nominated by the Astronomer Royal as chief of the transit of Venus parties, and to him all looked for completing each outfit. It was an arduous task, but not quite an unthankful one, as owing to his readiness to afford help and information, the parties after their return had no omission to reproach him with. The arrangements also involved a large increase in the work of the Astronomer Royal and of his chief assistant, Mr. W. H. M. Christie; their kindness and attention to the wants of all smoothed away difficulties after difficulties as they cropped up.

The Astronomer Royal had chosen the stations for the English parties principally to obtain results by Delisle's method, which was dependent on the accurate observation of the times of 1st or 2nd apparent internal contact of Venus with the limb of the sun, together with a close determination of the longitude of each station. If a figure be drawn showing the double zone formed by the shadow of Venus, and remembering that the planet crossed over the northern half of the sun's surface, it will be seen that certain places in the northern hemisphere would come into apparent internal contact with the inner zone sooner than localities in the southern hemisphere at ingress, whilst at egress the reverse would be the case. The difference in time of the observed contacts furnish the data by which the planet's distance (and hence the sun's distance) can be calculated. A glance at the accompanying map will show that the Russian Government expeditions occupied a line across Siberia and on to Japan, and it will be further noted that, owing to the prevailing bad weather, and to the low altitude of the sun, in the majority of cases the observations were unsuccessful. In Egypt, however, where there were parties of various nationalities, the necessary contacts at egress were observed, and they give ample data for Delisle's method, when the southern stations, which observed the same contacts, are taken into consideration. The most favourable stations, where successful observations for Halley's method were taken, will be at once seen in the map; that is those where the *difference* of the length of the chords, as measured by the interval of time elapsing between internal and external contacts, is greatest. For both methods it will be seen (if the observations have been well made) that the stations marked "successful" will give pairs, which, when combined, should give an accurate determination of the planet's distance. It can hardly be expected, however, that some discrepancies may not arise with visual observations, but supposing that

one half have to be rejected, yet, if the chances of error at each particular station be calculated, it will be found that there still remain abundant observations for the purpose required.

The phenomenon of the black drop or ligament connecting the planet with the sun's limb at the time of contact in very many stations was missing. This, together with the light ring round Venus, caused by its atmosphere, it is believed puzzled many observers, and perhaps may have caused them to record contact a little late. In one case, from my own knowledge, one observer was so engrossed in watching the line of light round the planet's edge, that he failed to record contact till 20 seconds after it had actually taken place.

Photography, however, cannot err in this manner, and from the results produced at various stations, there seems to be an absolute certainty that the correct time of contact at these stations will be known. Photographs of the sun, when visible, were taken by the English parties at intervals of every two minutes while the transit was taking place. The planet's central distance from the sun's centre is now being accurately measured, and it has been found that such measurements are comparable to the $\frac{1}{10}$th second of arc, a result which is four times better than was anticipated. It may prove that the photographic results are more reliable than those obtained by the eye observations; at all events, it is presumable that they will be equally trustworthy, and will therefore be great checks on the accuracy of the latter. The spectroscopic observation of the contacts has led to a supposition that the diameter of the sun's disc which emits so-called actinic rays is not quite coincident with that which emits the visual rays. Be this well founded or not, it is quite evident that the times of contact formed photographically must be comparable, whilst those arrived at by visual observations may have to be taken by themselves.

The longitudes of the English stations, except one, were obtained by the method of observing moon culminating stars and the transit of the moon, and involved an arduous series of observations extending over several lunations.

The exceptional station referred to was Cairo and Egypt generally, where the telegraph was used for obtaining true Greenwich time. All the Egyptian localities selected were connected by telegraph, and thus no difficulty was found in accurately determining the longitude of both Thebes and Suez. In the map it will be seen that some stations obtained their longitude by chronometers. The number of chronometers used ensured accuracy, and the longitude obtained by this method may therefore be relied upon.

My thanks are due to Captain W. A. Orde Browne, late R.A., for the loan of a tracing of a map showing the successful observing stations. A reduction of his original map appeared in *The Engineer* last year.

W. de W. A.

APPENDIX I.

Table showing Observers, &c., at the English Station.

COUNTRY.	STATION.	OBSERVERS.	Photographic Assistants.
Egypt	Cairo	Capt. Orde Browne, late R.A.	
		Mr. Newton	
		*Mrs. Orde Browne	
		*Miss Newton	
	Thebes	Capt. Abney, R.E.	Sapper Laffeaty
		*Colonel Campbell	2nd Corpl. Mitre
		*Mrs. Campbell	Sapper W. Farr
	Suez	Mr. Hunter	
Sandwich Islands ..	Honolulu	Capt. Tupman, R.M.A. ...	Sapper M. Meins
		Lieut. Ramsden, R.N....	Sapper G. Currey
		Capt. Noble, R.M.A, ...	Sapper W. Myers
		*Capt. Eaton, R.N.	
	Hawaii	Professor Forbes.....	
		Mr. Barnacle	
	Atooi.....	Mr. Johnson.....	
		*Rev. — Dunn	
Rodriguez	.....	Lieut. Neate, R.N.	Sapper F. Taylor
		Lieut. Hoggan, R.N.	Sapper T. Currie
		Mr. Burton	
		*Com. Wharton, R.N.	
New Zealand.....	Burnham	Major Palmer, R.E.	Corporal Sharp
		Lieut. L Darwin, R.E....	2nd Corpl. White
			Sapper G. Higgins
	Naseby	Lieut. Crawford, R.N. ...	
Kerguelin	Royal Sound..	Rev. J. Perry	Sapper Hilbert
		Rev.— Sidgreaves	Corporal Wright
		Mr. T. Smith	Lance Corp. Wilson
		Lieut. Goodridge, R.N. ...	
	Port Palliser ..	Lieut. Corbet, R.N.....	
		Lieut. Coke, R.N.	

Those Observers with * before their Names were not officially recognised as part of the Expedition.

APPENDIX II.

DRY-PLATE PROCESS FOR SOLAR PHOTOGRAPHY.

Extracted from the Official Instructions to Observers.

By Captain W. de W. Abney, R.E.

Before commencing the preparation of the plates, some fresh eggs (say four for a dozen medium-sized plates) are procured, and the whites carefully beaten up (with one drachm of liquid ammonia to each white) by a whisk, a bundle of quill pens, or by shaking in a bottle into which fragments of glass have been introduced. When the froth has subsided, the clear fluid is procured by filtering through muslin, and is placed in a bottle labelled A. A glass of bitter or mild ale is next obtained, and to half of it (which should be 5 oz.) 10 grains of pyrogallic acid are added, and the solution, if necessary, is filtered through filter paper. This is lettered P. The other 5 oz. of beer are placed in another bottle and labelled B.

Should the fresh eggs not be obtainable, dried albumen may be used; 20 to 25 grains of the latter should be dissolved in an ounce of distilled water, and substituted for them.

Bottled beer may also be substituted for the ordinary bitter ale. Care should be taken that, by a gentle heat, the carbonic acid is all liberated, otherwise carbonate of ammonia will be formed on the addition of alkaline albumen.

(i.) Any ordinary collodion will answer. The bromo-iodized sample supplied by Thomas, of Pall Mall, with two grains of pyroxyline added to each ounce, gives very rapid results.

For sun-pictures, however, a modification is advisable; and much will depend on the climate in which it has to be employed.

(ii.) For a cold climate, collodion made by the following formula will be found to give good results :—

Thomas's bromized collodion	20 oz.
„ ordinary bromo-iodized do	20 oz.
Plain collodion, *not* iodized	6 oz.
Pyroxyline	276 grains.
Water	400 minims.

(iii.) For warmer climates the following will be found to answer better :—

Thomas's bromized collodion	20 oz.
„ bromo-iodized do	20 oz.
*Alcohol, sp. gr. ·805	6 to 8 oz.
Pyroxyline	300 grains.
Water	120 minims.

With (i.) the ordinary nitrate of silver bath, 40 grains to the ounce is used. If greater sensitiveness is required, 10 grains of nitrate of uranium to each fluid ounce of the above are added.

With (ii.) and (iii.) the above bath should be used, together with another made 60 grains to the ounce of water.

* The hotter the climate, the more alcohol will be required.

A substratum to the collodion is recommended, to insure adhesion of the film to the glass plate during development. This is made by mixing the white of one egg with 40 oz. of distilled water, and applying it to the surface of the plate by a piece of swan's down, calico, or flannel, folded over the edge of a strip of glass and used as a brush. The brush is dipped in the fluid, and drawn down the plate in parallel lines till the whole surface has received a coating. Here I may mention that a *clean* plate is necessary; but *much polishing with a silk handkerchief or chamois leather prevents the substratum taking kindly to the glass.*

Another substratum, which seems to give almost better results than the albumen, may be substituted for the above:—

Sheet gelatine	75 grains.
Distilled water	60 oz.
Ammonia	$\frac{1}{2}$ oz.
Alcohol	1 oz.

The gelatine should be softened in 30 oz. of cold water, and then dissolved by 30 oz. of boiling water. When cold, the remaining ingredients should be added.

If a plate (after the substratum has been thoroughly dried) is coated with collodion (i.) it is sensitized in the ordinary manner in the 40-grain bath, *i.e.*, for about 4 min. in cold to $2\frac{1}{2}$ min. in warm weather. If the plate has been coated with (ii.) or (iii.), it is plunged in the 40-grain bath and kept there till all "greasiness" has disappeared. It is then transferred to the 60-grain bath, and kept there for 7 or 8 minutes longer, *i.e.*, until a creamy film is obtained. The plate is next plunged into distilled water, or spring water, which has been rendered slightly alkaline by adding a few dops of ammonia to it (if iron be present as an impurity), and to which, *after boiling and filtering*, a few drops of nitric acid have been added to restore neutrality. When the "greasiness" has disappeared from the film, the plate may be washed under the tap for a minute, or in different dishes of water, until all free nitrate of silver is got rid of. (This may be effected rapidly by adding a pinch or two of common salt to the last washing water but one in the dishes.) In a small tumbler are next mixed equal quantities of A and B, stirred up with a glass rod, and floated over the washed film. If all the nitrate has not been washed away, stains may here become manifest. This solution is kept on half a minute, and is then poured off. The plate is once more thoroughly washed, and solution P is floated over for another half minute. The plate is then set up on one corner to dry spontaneously. Before being stored away, the last trace of moisture may be expelled by gently warming over a stove or Bunsen burner. In dry climates this precaution need not be taken. As a rule, the plate requires no "backing" to prevent blurring of the image; but if it appear very transparent a backing may be necessary. Cartridge paper stained with any red dye (alkaline aurine will answer), and coated with gum and flour stained of the same colour, will give what is required. When damped, the paper will adhere to the back of the plate, and dry in optical contact with it. It can easily be removed by wetting.

The exposure is the same as that necessary for a wet plate prepared with the

same collodion, though no damage will be done to the picture if six times that amount be given. With the uranium bath the dry plate is quicker than a wet plate.

The development need not take place for a month after exposure. The following solutions must be made up:—

No. I.	Pyrogallic acid	12 grains.
	Water	1 oz.
No. II.	Liquor ammonia	1 part.
	Water	4 parts.
No. III.	Citric acid	60 grains.
	Glacial acetic acid	30 minims.
	Water	1 oz.
No. IV.	Nitrate of silver	20 grains.
	Water	1 oz.

The plate is washed in spring or rain water of a not less temperature than 60° F. till all the beer has been removed. Sufficient of No. I. is taken to well cover the plate, and first flowed over it. Into the developing cup are then dropped three drops of No. II., and No. I. is poured off the plate on to it. The solution is then flowed over the plate again, and after a few seconds the detail will begin to appear by *reflected* light. As detail appears, another two drops of No. II. may be added, and so on till *nearly* all the detail is visible. The plate is now washed in water of the same temperature. Here it may be remarked that stronger doses of No. II. may be used to *under*exposed pictures. Six drops of No. III. are next dropped into a clean developing-cup, and the same quantity of No. I. added as before. This is flowed over the plate to neutralize any trace of ammonia remaining. Into the cup are now dropped two drops of No. IV., the pyro. solution from the plate poured on to it, and once more applied to the film. The image will gradually acquire strength, the remaining detail appearing. The intensity is gained by adding to the same or fresh *(acid)* pyro. solution more silver (No. IV.). When the image appears of sufficient density, it is fixed with a solution of hyposulphite of soda or cyanide of potassium. In the case where the plate is backed, the film should be wetted first, and then the paper removed.

The alkaline development produces a faint image by the reduction of the organic salt and bromide of silver to the suboxide of silver. The iodide is unattacked by it. The acid silver development utilizes the exposed iodide thus—the attraction of the suboxide for fresh silver (deposited by the acid development) is increased by the irritated iodide, and thus density is acquired.

It will be noticed that no restrainer, such as bromide of potassium, is used with the alkaline development. The albumen dissolved by the ammonia plays the part of a retarder, but not of a destroyer. Thus the image is well under control.

An *under*exposed picture has an image of slate colour; an *over*exposed picture has one of an olive green; whilst one properly exposed is of a rich chocolate brown. Every plate sufficiently exposed will yield a good negative.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PAPER X.

ABSTRACT OF METEOROLOGICAL OBSERVATIONS TAKEN AT THE ROYAL ENGINEER OBSERVATORY, CHATHAM, DURING THE YEAR 1875.

COMMUNICATED BY CAPT. FELLOWES, R.E.

Latitude, 51 *deg.* 23 *m.* 37 *sec. N. Longitude*, 0 *deg.* 32 *m.* 12 *sec. E. Height of Cistern of Barometer above Sea Level*, 120 *feet.*

	Inches.	
Highest reading of the barometer corrected for temperature was	30·603.	31st Jan.
The mean height " " "	29·984.	
The lowest " " "	29·051.	11th Nov.
	Degrees.	
Maximum temperature of air in shade	85·0.	16th Aug.
" " " at 9 a.m.	78·2.	"
Mean temperature of air in shade	49·5.	
" " " at 9 a.m.	51 2.	
Minimum " " at 9 a.m.	26 2.	1st Jan.
" " "	14·5.	"
Greatest amount of Humidity at 9 a.m.	1·000.	
Mean " " at 9 a.m.	·822.	
Least " " at 9 a.m.	·450.	25th Apr.

There were frost and snow in February, March, November, and December. During the night of the 30th of November, snow fell to the depth of two inches, increasing in depth to five inches on the 6th of December, and remained on the ground until the 13th of December. The limiting nights of frost were the 11th of March and the 20th of November.

Thunder and lightning occurred on the 19th of May, 11th of June, and 24th of September. Lightning without thunder was observed on the 3rd of August.

Meteors were observed on the 15th of March and 11th of December.

TABLE—Showing the mean height of the barometer; mean temperature of the air in shade; mean temperature of evaporation and mean humidity (at 9 a.m.) and approximate mean temperature of the air in shade during each month of the year.

MONTH.	Mean height of Bar. corrected and reduced to 32 deg.	Mean temperature of air at 9 a.m.	Mean temperature of evapr. at 9 a.m.	Mean temperature of dew point at 9 a.m.	Mean elastic force of vapour.	Mean humidity at 9 a.m.	Self-registering Ther.		Mean temperature of air.
							Mean Max.	Mean Min.	
January	29·947	43·2	42·3	41·0	·266	·903	47·2	38·6	42·8
February	30·045	35·4	34·3	32·8	·189	·903	40·8	30·6	35·4
March	30·091	41·0	38·7	35·7	·214	·748	45·6	34·1	39.8
April	30·059	48·5	45·1	42·0	·270	·795	55·0	38·1	46·5
May	29·979	58·5	53·5	49·2	·355	·722	65·2	47·6	56·4
June	29·890	62·2	57·3	53·0	·409	·724	68·3	52·0	60·1
July	29·950	60·9	57·3	54·6	·426	·796	65·6	52·0	58·8
August	30·030	64·9	60·8	57·4	·480	·771	70·9	55·9	63·4
September	30·048	63·0	59·4	56·3	·460	·793	68·4	54 1	61·2
October	29·796	54·1	48·9	47·0	·328	·866	56·2	44·1	50·1
November	29·829	43·0	41·6	40·0	·252	·894	47·8	37·1	42·4
December	30·144	39·8	38·6	38·9	·234	·954	41·2	33 4	37·4
	29·984	51·2	48·1	45·7	·323	·822	56·0	43·1	49·5

TABLE—Showing the direction and mean force of the wind, the number of days it blew from each point, the number of days on which rain fell, and the depth of rain, in inches, during each month of the year.

Month.	N.		N.E.		E.		S.E.		S.		S.W.		W.		N.W.		Calm.		Total.		Mean velocity of wind in miles per hr.	Rain.		
	Days.	Rain on.	Days.	Rain on.	Days.	Rain on.	Days.	Rain on.	Days.	Rain on.	Days.	Rain on.	Days.	Rain on.	Days.	Rain on.	Days.	Rain on.	Days.	Rain fell.		Total Depth.	Greatest fall in 24 hours.	
																						inch.	inch.	Day.
January	..	..	1	1	..	..	3	1	5	4	12	7	8	6	2	2	..	..	31	21	9·3	2·50	·49	30th
February ..	4	..	9	5	2	2	2	..	1	1	4	2	2	..	4	1	..	..	28	11	10·4	·55	·14	20th
March	7	2	6	1	5	..	1	..	5	1	1	1	2	..	4	..	..	..	31	5	12·0	·31	·24	8th
April	..	..	16	3	1	..	2	..	..	..	5	1	4	1	2	..	..	..	30	5	8 0	·47	·31	22nd
May	..	..	8	2	..	..	1	..	..	..	15	4	4	1	3	..	..	..	31	7	9·3	·24	·12	6th
June	..	..	6	2	..	..	..	..	..	..	18	7	8	2	3	..	..	..	30	11	5·0	1·89	·49	29th
July.....	..	..	13	6	3	1	..	..	..	..	1	3	4	..	10	5	..	..	31	15	4·4	4·22	1·22	16th
August	1	..	10	2	..	..	..	..	1	1	15	2	..	..	4	1	..	..	31	6	3·0	1·11	·70	29th
September ..	..	..	5	..	..	..	5	2	4	1	10	5	2	..	4	1	..	..	30	9	5·0	2·10	·81	24th
October	1	..	1	..	3	2	11	6	5	3	7	1	1	..	2	1	..	..	31	13	5·0	3·16	·60	2nd
November ..	3	1	8	2	..	..	5	1	..	..	13	10	1	..	..	..	..	..	30	14	6·0	4·01	·80	8th
December ..	..	..	20	2	..	..	..	..	..	..	1	..	7	3	1	..	2	..	31	5	4·0	·30	·10	21st
Total ..	16	3	103	26	14	5	30	10	21	11	97	43	43	13	39	11	2	..	365	122	..	20·86	..	..

The greatest fall of rain in twenty-four hours measured 1·22 inches, and was on the 16th July. The average fall for every day in the year was 0·057 inch, and for each wet day was 0·17 inch.

The amount of ozone this year was greater than that of the previous year; its mean daily number would be represented by 2 on the scale. Its presence was greatest during the months of May, June, August, September, and December.

Comparison of mean results for seven years.

Years.	Mean height of Bar. corrected for temperature.	Mean temperature of air at 9 a.m.	Mean temperature of evapr. at 9 a.m.	Mean humidity at 9 a.m.	Self-registering Thermometer.			Rain.	
					Mean Max. in air.	Mean Min. in air.	Mean in air.	Inches.	Days.
1869	29·769	58·7	..	·810	..	..	..	25·99	118
1870	29·844	49·9	..	·816	..	..	..	19·11	102
1871	29·833	50·0	47·2	·828	56·2	42·6	49·4	22·69	127
1872	29·680	51·7	48·9	·822	59·8	44·5	52·0	31·84	187
1873	29·834	49·3	47·7	·814	60·0	41·4	50·7	18·74	128
1874	29·842	50·6	47·8	·816	57·2	42·5	49·9	16·62	128
1875	29·984	51·2	48·1	·822	56·0	43·1	49·5	20·86	122
Mean.	29·826	51·6	47·9	·818	57·8	42·8	50·3	22·26	130

The prevailing direction of the wind during rain, in each year, was South, South-West, and North-East.

The height of the rain guage above sea level is 115 feet, and above the ground one foot.

1875

Monthly means of Meteorological Observations and Monthly Rainfall at Chatham. PLATE XIII.

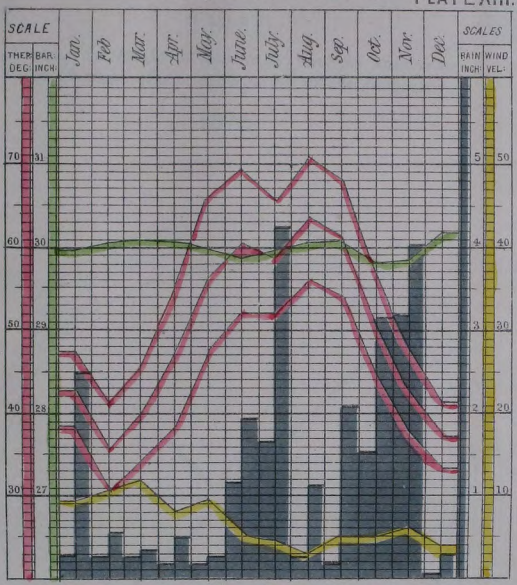
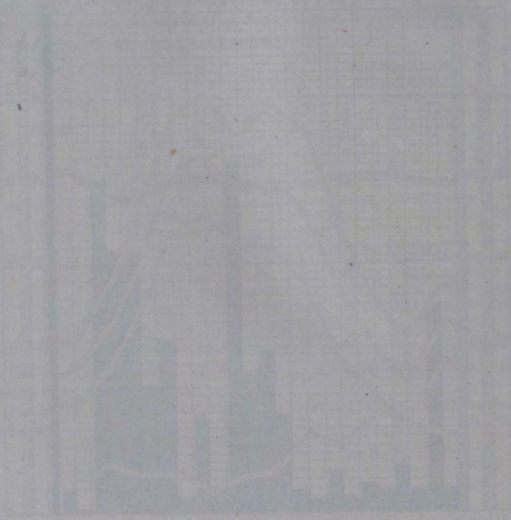


Diagram shewing the number of days in each month of the year the wind blows from each point of the compass at Chatham

Month	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
N		3	3					1		1	3		16
NE	1	4	5	6	5	5	6	5	3	2	4	6	103
E		2	4	1			3			3			14
SE	3	3	2	2	1				3	5	3		30
S	3	1	3					1	3	3			21
SW	5	3	1	3	5	4	1	5	5	4	4	1	97
W	4	2	2	3	3	4	3	2	2	2	2	3	43
NW	2	3	3	3	2	2	4	3	3	2		1	39
C												2	2

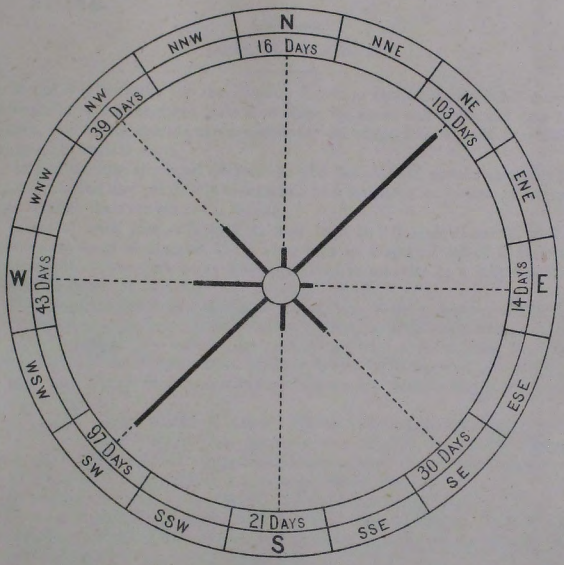
S M E. Chatham. *Note-Each dot represents one day.*



CHART

Shewing the number of days in the year the wind blows in Chatham from each point of the Compass.

1875.



Scale

Days 20 0 20 40 60 80 100 120 140 Days

S.M.E. Chatham.

PAPER XI.

EXPERIMENTS UPON BEAMS OF PORTLAND CEMENT CONCRETE, AND SOME NOTES ON ARTIFICIAL STONE.

By Lieut. E. WOOD, R.E.

In the new barracks for the Brigade Depôt at Guildford, Portland cement concrete is used throughout, instead of stone, for floors and steps, and also for lintels, sills, string courses, copings, chimney-dressings, &c., when it is worked up so as to imitate stone.

At first starting, it seemed desirable to test the value of certain materials in such work, and also practically to ascertain how far variation in form of section would affect the strength of the floors.

A row of brick piers, 2 ft. by 2 ft., were built at 8 ft. clear intervals, and a continuous beam of concrete, 12 in. wide, with an average depth of 12 in., was cast over them, the piers being then continued in concrete to a height of 3ft. above the beam (Pl. XV., fig. 1).

The materials used were:—Portland cement from Halling, duly tested; Farnham gravel, washed and screened; broken "burrs," or hard burnt bricks; sharp pit sand, washed. The concrete was not in any way prepared more carefully than usual, so that similar results might be looked for in the work generally.

The various proportions and other particulars are given on the table accompanying Fig. 1.

No. 1 Experiment. In 20 minutes a load of 5,138 lbs. had been applied at the centre, when a slight crack appeared at *a* (Fig. 1), the deflection being $\frac{3}{16}$ in.; after which the load was gradually increased with the following results:—

27 minutes, 6,314 lbs.; crack *a*, 9 in. deep; deflection $\frac{3}{8}$ in.

34 minutes, 6,566 lbs.; slight cracks at *b* and *c*; deflection $\frac{7}{8}$ in.

36 minutes, the left hand pier and wall were thrust bodily out $1\frac{1}{4}$ in. at the foundations, which we may for practical purposes consider due to the action of the bent lever shewn by dotted lines in Fig. 2.

No. 2. The pier B (Fig. 2) was strongly strutted, and in 20 minutes 4,900 lbs. had been applied with no sign of yielding, when B was lifted completely off its bed and the beam broke, but was received on a block to prevent complete fracture, and thus to form an efficient abutment for the next trial.

No. 3. 20 minutes, 4,100 lbs.; slight crack at a; deflection $\frac{13}{16}$ in.

25 minutes, 5,596 lbs.; a, 9 in.; slight crack at c; deflection $\frac{7}{16}$ in.

28 minutes, 5,821 lbs.; c, 6 in.; crack at b.

32 minutes, 6,063 lbs.; a, $9\frac{1}{2}$ in. and $1\frac{1}{4}$ in. wide at bottom; b and c, 9 in.; deflection $1\frac{1}{8}$ in.

35 minutes, 6,445 lbs.; piers D, E, F, G, fractured and moved bodily by the thrust; C uninjured, beam broke down (fig. 3.)

The abutment at G, being too weak, was still more heavily weighted, and the last beam with its load formed an efficient abutment as before.

Nos. 4, 5, and 6 beams were now loaded simultaneously, and in $1\frac{1}{2}$ hours, 5,180 lbs. had been applied to each with the following results:—

No. 4. A slight crack at a; deflection $\frac{1}{4}$ in.

Two hours, 6,000 lbs.; a, $8\frac{1}{2}$ in.: deflection, $\frac{3}{8}$ in.; no crack was visible at b and c, but as one pier shewed signs of yielding, no more weight was applied. This however, remained on three days, producing a total deflection of about $\frac{7}{8}$ in., which on removal of the load ultimately became $\frac{1}{8}$ in. only; it is not possible, however, to say how much is due to elasticity of the beam, and how much to the reaction of the abutments.

No. 5. After the load had been increased to 8,950 lbs. in three hours, a very slight crack appeared simultaneously at a, b, and c; deflection $\frac{1}{4}$ in. Four hours, 1,400 lbs.; a, $4\frac{1}{2}$ in.; b and c, 16 in.; deflection, 1 in.

As the piers had commenced to settle, no more weight was applied, but this remained on three hours, producing a deflection of $1\frac{1}{8}$ in., after which 11,000 lbs. remained on three days, increasing the deflection to $1\frac{1}{4}$ in., the crack a still being $1\frac{1}{2}$ in. from the top of the beam.

On removing the load a very slight disturbance of the upper surface above a was seen, due to compression, and the ultimate deflection decreased to $\frac{1}{2}$ in. (Fig. 4).

No. 6. In $3\frac{1}{2}$ hours the load had amounted to 9,600 lbs., producing slight cracks at a and c, with a deflection of $\frac{5}{16}$ in. This remained on one hour, and afterwards 8,500 lbs. remained three days; the deflection became $\frac{3}{4}$ in., but fell to $\frac{3}{8}$ in. on removal of the load. The abutment G was not quite rigid enough to give true results.

Although in consequence of want of stability in the piers no satisfactory test of the strain required actually to break down the beams could be applied, yet as far as they go they would show that with beams so fixed (where the force to resist compression can be fully exerted) the results with brick and gravel are about the same.

The addition of sand probably weakens the concrete, but owing to a mistake no two beams fairly compare as regards this point.

Assuming that the top of the beam must be flat, then the proportions adopted in Nos. 5 and 6 appear to bring the full tensile strength into play simultaneously at a, b and c, and it would require a distributed load of $21\frac{1}{2}$ cwt. per ft. super to produce signs of yielding in such a beam as No. 6 when only one month old.

No deflection in any instance could be perceived before the appearance of the

first crack, proving, as might have been expected, that the concrete cannot be perceptibly stretched, although its elasticity under compression is probably proved.

Blocks of gravel concrete when merely supported were found to be very weak. For instance, a block two months old composed of one cement and four gravel (screened through 1 in. mesh and washed), 13½ in. wide and 8½ in. deep, was supported at an interval of 4 ft., and fractured by 5 cwt. applied at the centre; whereas a block of similar dimensions in which breeze from gas works had been used instead of gravel, was only fractured by a load of 3,100 lbs. applied over the central 15 in., the supports being as before. This block which displayed such great tensile strength was only 27 days old; the fracture was most uniform.

Again, beams of all descriptions when merely supported, broke down readily under the application of blows. As an example, one made with ashes or breeze as above, but 9 in. wide, 6 in. deep, and 20 days old, was supported at an interval of 3½ ft. A put-log, weighing 17½ lbs. was dropped endwise on the centre from a height of 2 ft., when the beam broke at once, although the fracture proved excellent.

It seemed desirable to ascertain the behaviour under blows of beams when *fixed*, and as gravel appeared likely to be the weakest, a block was tested similar in every respect to that which broke at 5 cwt., but a few days older. (Fig. 4.) The ends were bedded in cement, and solidly built up for nearly two-thirds their height across a doorway at the base of a heavy tower, with walls 3 ft. thick. The span was 4 ft. 2,000 lbs. of iron was first laid over the central 18 in., and then a girder weighing 410 lbs., was dropped flat from heights of 1, 2, and 3 ft. The load of iron was now removed, and the same girder dropped directly on the centre from heights of 1, 2, 3, 4, and 5 ft., when a slight crack appeared at *a*.

After a lapse of three weeks, during which heavy loads were sometimes taken across the beam, the experiments were continued. The same girder was dropped 1, 2, 3 ft., and again 3 ft., when the test was stopped, as the abutments being brickwork in mortar, were susceptible of some amount of compression, and therefore might allow the ends of the block to move slightly. Results:—crack *a* to within ½ in. of top, and small bit fallen out of it, while its general width across bottom was $\frac{1}{16}$ in.; crack across corners *b* and *c*; ends slightly lifted from bed; deflection $\frac{5}{16}$ in.

This confirmed previous deductions, that all concrete beams when rigidly fixed, so that the ends cannot move outwards, possess great strength, although tensile strength is only exhibited to any great extent by beams made with porous materials.

Again, it is clear that if the ends of the beam had been loaded, they could not have lifted, and the beam would therefore have stood a still greater strain, which shews the advantage of carrying a concrete floor into the side walls, and not merely supporting it on corbels.

Concrete can be run into moulds of any description, as described in Corps Papers, Vol. XXII., Paper XIII., by Major Maquay, R.E., and may then be worked up so as to imitate stone; but in order that the face may stand, certain

precautions are necessary. The moulds might be made out of 2 in. seasoned deal, and before being filled, might be brushed over with stone dust and water, in order to assist in turning the castings out. The concrete, of brick or breeze, well soaked, should be carefully punned in, with as little free moisture shewing as possible, and may as a rule, be safely turned out in 48 hours. The surfaces to be finished are now wetted and thoroughly rubbed down with a York stone, after which the smallest possible amount of cement, (2 cement, 1 river sand, 1 stone dust), is worked in with a float, so as to fill in interstices.

In place of stone dust, crushed brick might be used to give the desired colour to the face.

In winter, the castings should be made under cover, and stacked there for about a fortnight, a Gurney's stove being kept alight in the room where the finishing of surfaces is done. Care should be taken to keep water in the pan of the stove. It is very important that the cement for finishing all surfaces should not be fresh, and if possible it should be spread out on a floor in some building for a short time before being used. In any case, the tests for expansion and shrinkage should be regularly applied.

Some of the castings were heavy and intricate, and in such work a marked saving over stone is effected, especially where a number of one pattern are turned out. The bases for chimneys, where the upper shafts are twisted on the lower part of the stack, is a case in point.

A 9 in. flue pipe is inserted in the mould at any required angle to suit the flues, and the concrete run round it, partitions being inserted in the mould to cut off such parts as may be necessary where two or more flues come together.

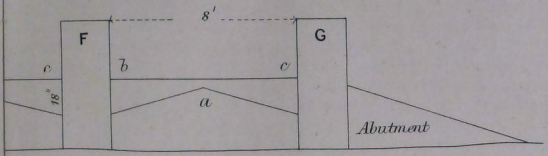
Staircases can be cast in one piece from top to bottom; and it is possible at the same time to cast a continuous balustrade, instead of fixing the ordinary balusters and handrails. The advantage of this is marked. The strength of the staircase is much increased; the side wall need be cut out only $4\frac{1}{2}$ in. for the steps, so that the whole may be put in after the rest of the work is done, a great convenience; and a balustrade of any pattern, simple or ornamental, may be cast at a less cost than the other.

The steps are put in with "burrs" (hard burnt brick) half an inch being allowed for a finishing surface of 1 cement to $1\frac{1}{2}$ fine washed grit; for the balustrades, however, breeze is used as being lighter.

A bricklayer and six labourers would put in two flights of ten steps each, with landing and balustrade, in a day, except finishing the surface.

In order to protect the edges of the steps from being chipped by blows from baggage boxes, &c., iron bars 2 in. by $\frac{3}{8}$ in., with top edge roughened, can be fixed along the top of the risers. The bar runs into the wall at one end and into the balustrade at the other, and is further tied in by one or more lugs, the whole being fixed in position as the staircase advances.

E. W.



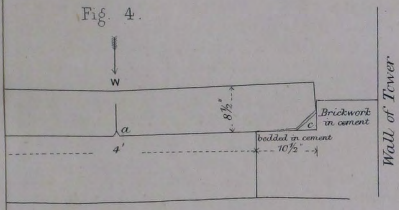
ays

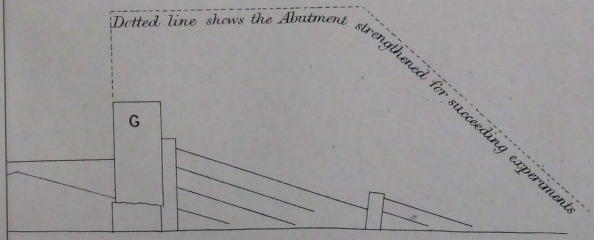
avel
")
d

Nº 6. 28 days

1 P.C. to 3½ Brick
(Screened ¾")
no sand
9600 lbs. Crack at a
_ Dº _ do at b or c

Fig. 4.





THOS KELL, LITH. 40, KING STREET, COVENT GARDEN.

PAPER XII.

ON THE ENGINEER OPERATIONS ON THE GOLD COAST DURING THE RECENT EXPEDITION.

By LIEUT. COLONEL HOME, R.E., C.B.

Sir,—In accordance with your orders, I have the honour to forward the accompanying report on the Engineer operations in Ashantee.

During the months of April, May, June, and July, 1873, I had been employed in preparing and helping to prepare, in a tangible form, the small amount of information that existed as to the country.

On being ordered to the Gold Coast, I naturally considered what duties I should be called on to perform. I knew the intention was first to clear the area termed the British Protectorate of the Ashantees; secondly, to march on Coomassie, the capital of the Ashantee King.

There were two ideas which I felt convinced were at the root of all successful military engineering, and I determined to make these ideas the guide of my actions in all things—

1. That the engineering must be adapted to the country, not the country to the engineering.
2. That a rough, ugly erection, ready when wanted, and answering its purpose, was of far greater value than a neat, artistic production, which was only ready after the necessity for its use had disappeared.

I carefully examined all the information I could obtain as to the nature of the country, and the resources available to overcome the material difficulties opposed to the carrying out of the General's plans.

The information as to the nature of the country was very meagre, and the ideas conveyed by the various books that were obtainable turned out, in many cases, to be erroneous.

Generally, it appeared that the country between Cape Coast Castle and the Prah was covered with a dense, impenetrable forest; that it was low and marshy, much intersected with streams; that the timber was all hard wood, and of immense size; that the roads or paths were mere tracks, from 9 in. to 3 ft. wide; that labour was exceedingly difficult to procure, and very bad; that the native population was small, and scattered over a great extent of country; that the seasons were divided into a very rainy season, from March to December, and a less rainy season, termed the dry season, from December to March; that at all

The Deputy Adjutant General,
Royal Engineers.

times there were frequent tornadoes, of great violence, and accompanied with heavy rain; that supplies of food were difficult to procure; and that at both seasons the climate was unhealthy, though less so during the dry season; that Europeans could with difficulty live, and could not possibly work; and that there was at least one formidable river, the Prah, to be crossed.

Such being the ideas as to the nature of the country to be operated in, as derived from books, after much anxious consideration, I came to the conclusion that (bearing the ultimate success of the Expedition in view) it was not only desirable, but absolutely requisite, to reduce the engineer means, both as to *personnel* and *matériel*, to a minimum.

Further, that modern scientific appliances which required large numbers of Europeans to work them were out of place; that the part the Engineers would have to play would not so much be that which modern European war has shown to be their position—"rendering the success gained by an impetuous attack secure by quickly throwing up field works behind the attacking force, and in the same manner stopping a retreat by hastily-constructed entrenchments, the holding of which then concerns the honour of the troops"—as the humbler, but not less important one, of acting as pioneers, opening up the country, making roads, bridges, and attending to the sanitary wants of the army.

Having conceived these views of the duty which I and those under my command would have to carry out, I gave Sir Garnet Wolseley a memorandum on the engineer arrangements which I proposed.

The tools demanded were intended to be for immediate engineer use only. I was informed that large reserves of tools of all sorts were being taken out, and that I was only concerned with the tools required for the actual wants of the Engineers. (*Vide* Appendix II.)

These lists were too small; they were subsequently increased by about one-half, a steam sapper and a saw bench being added. Even with this increase I have no hesitation in saying that I erred in demanding too few articles.

When this country makes war, her base of operations must be some place beyond the sea, and officers in charge of such operations as those that fell to my share would do well to remember that a liberal supply of tools and matériel costs merely their transport or freight to the point of disembarkation.

It was fortunate that many tools were in the Colonial stores, and that subsequently large numbers were sent out for purposes not at first contemplated.

The value of experience gained in such expeditions as that of 1873—74 is, perhaps, rather negative than positive; and I hope the error which I am quite conscious of having made may not again be repeated.

Having examined all the information I could obtain as to the store accommodation at Cape Coast Castle, and obtained from the Deputy Controller what information he could give me on the amount of accommodation that he required for his stores, I became strongly impressed with the absolute necessity of taking out a large number of store huts, in order that the large quantity of rice, flour, and other perishable articles, might be protected from the weather.

I therefore obtained the sanction of the Surveyor General of the Ordnance

(Sir H. Storks) to the provision of 70 huts (*vide* Pl. XVI.) 30 of which were to be sent out with the steamer in which Sir Garnet Wolseley and the first officers embarked.

These huts were, as will be seen, very roughly made. They were framed in London, taken to pieces and put together in bundles (all the corresponding pieces of one hut being put up together and hooped with hoop iron, certain spare bits being introduced), each hut being numbered and lettered, and the nails, locks, bolts, &c., with tools for putting the huts together, being all carefully put up in separate boxes.

Nothing could be better than the way in which these huts were arranged (*vide* Appendix III.) They were 18 ft. by 14 ft., and it was proposed to put them up either 18 ft. by 14 ft., 36 ft. by 14 ft., or 54 ft. by 14 ft., as might be required. The dimensions of the huts and the scantlings were fixed by myself. The latter were quite sufficient for the purpose; the former would have been better if 16 ft. in place of 14 ft. had been adopted; the additional length of timber would have been slight, and the huts, when used as hospitals or barracks, would have held two rows of beds in place of one. The desire to keep these huts light induced me to adopt the width 14 ft., but the advantages of 16 ft. are so great, that it more than counterbalances the additional weight.

The questions of a railway and a telegraph were much canvassed in England prior to the departure of the Expedition. Both were really questions as to the supply of materials and labour.

If the materials requisite to make a line of railway could be landed at Cape Coast in sufficient time, and labour sufficient to perform the unskilled portion of the work could be procured, there could possibly be no reason why a railway should not be made; its advantage when made was undoubted.

With regard to the telegraph, the only questionable point was the ability of the Europeans to stand the work of putting it up.

My opinion, as given to the Major General Commanding, was opposed to both; the railway, because I did not believe the materials could be delivered in time, or the labour provided; the telegraph, because I was doubtful as to the capacity of the Europeans to resist the climate if much exposed in the months of October and November.

The result showed that, so far as the railway was concerned, I was right; but I was wrong as regards the telegraph; and I have always regretted that a telegraph, with men to put it up, did not form a portion of the stores taken out in the "Ambriz."

I feel convinced that the advantages of having telegraphic communication to Dunquan, Abracrampa, and several other places, would, in the earlier stages of the Expedition, have been invaluable.

I did not propose to take out any signalling apparatus. Some boxes of field signalling apparatus were sent out, but were not used. I often regretted that a shutter apparatus with a lime light, to communicate with the ships, was not taken out. A semaphore, worked by the navy, was used; but I believe a proper fixed shutter, with lime lights both at Cape Coast and Elmina, would have been most useful.

But to use such apparatus European rank and file were required, and it was undoubtedly wise to reduce this rank and file to the lowest figure, until the season was sufficiently advanced to what we knew was the dry month, or until the country was opened up.

Invaluable as the telegraph would have been to Abracrampa, it should be borne in mind that the men making it would have suffered greatly, there being no accommodation for them on the path; for the road was unmade and the swamps and streams unbridged.

The questions of a railway and a telegraph were really amongst those that could not be decided in England, the information and (as the result showed) the incorrect information that was available being too meagre to enable any person to give a very definite opinion.

With the view of making some distinction between the Engineer labourers and others, I requested to be supplied with 200 round brass labels, to be hung round the men's necks; these were marked "Engineer Company," and numbered 1, 2, 3, &c. 800 round zinc labels, marked "Engineers," were also provided, each with a piece of hambro line to hang round the men's necks.

These labels were found of great value, but some little confusion was caused in the latter stages of the Expedition by the 42nd Highlanders having had issued to them similar labels with "R.H." on them. At a distance, the distinction between an engineer labourer and a 42nd carrier could not be seen.

The Major General and officers composing the first portion of the Expedition embarked on the 12th, at Liverpool.

In the many and confidential conversations which I had the honour to hold with Sir Garnet Wolseley during the voyage, I was enabled to arrive at what I conceived to be his wishes as to the method of conducting the engineering operations. And here I should like to say that I do not think any Commanding Engineer could have greater latitude allowed to him than was given to me by Sir Garnet. In every way he left me unfettered to carry out my share of the duties. And the feeling that I was so unfettered, that he fully trusted me and gave me, as it were, complete control over my own branch, was the strongest inducement that I could have had to carry out the work assigned to me, precisely as he wished to have it done.

I have ventured to state the obligations I was under to Sir Garnet Wolseley in this respect, as I feel convinced that the greatest portion of the success of the engineer operations was due to the fact that Sir Garnet told me clearly what he wanted done, and when he wanted it done, and left me then to deal with the means at my disposal.

By thus knowing what devolved on me, I was enabled to organise the labour and material at my disposal, and to effect far more, and at a far smaller cost, than if I had been situated differently.

I felt sure of support; I worked accordingly, and I believe that such a system is at the base of all proper military organisation, whether in peace or war.

Constant interference irritates and frets men.

The head of any branch must have his own ideas, and, if he be a man worth having, he must think out for himself how his duties should be performed.

An attempt to dictate and direct from day to day about every trifle simply converts an intelligent subordinate into a blind tool.

Treated by Sir Garnet Wolseley as I have described, I strove to imitate, and apply that treatment to my subordinates, and in every case with success.

On arriving at Sierra Leone, on the 27th September, Sir Garnet Wolseley published a General Order by which he appointed me as his Commanding Royal Engineer, and I fulfilled the duties of that office during the campaign (*vide* Appendix IV.)

I believe few officers who have had difficult duties to perform in the field, have ever been better supported by their subordinates than I was.

Major Jones, Captain Buckle, Lieutenants Bell, Jekyll, Mann, Skinner, and Cotter, R.E., Lieutenants Hare, 22nd Regiment, and Hearle, R.M.L.I., worked unceasingly in carrying out their various duties.

Sergeants Dunne, Langstaff, Dowie, Loxton, Taylor, Page, and Dodson; Corporals Dickson, Annets, Roberts, Barthorpe (deceased); Sappers Brook, Little, Coulson, Hough, and indeed all the non-commissioned officers and men behaved well and did their duty zealously.

The naval detachment placed at my disposal by the Commodore, gave me the greatest assistance, and my thanks are due to them individually for their exertions.

I have the honour to be,
Sir,
Your most obedient Servant,
R. Home, Major, C.R.E.

On the publication of the General Order referred to, the Ashantee Expedition was really constituted, and the work of the campaign fairly began.

The following report, or journal of the campaign, is compiled from the journal kept in the Engineer Office at Cape Coast Castle, and from the journals kept by myself and other officers. It is intended to be merely an engineer journal, and, consequently, other events in the campaign will not be touched on, except in so far as they intimately concern the engineer operations.

Prior to the expedition leaving England, a letter had been written directing Mr. Jenkins, the Colonial Engineer at Sierra Leone, to get together about 60 artificers, viz., about 30 carpenters, 10 smiths, and 20 good labourers (*vide* Appendix V).

On landing, Mr. Jenkins was found to have these men prepared. They were paraded, when the terms were explained to them, and certain men refused to go. The numbers were consequently reduced to 30 carpenters, 3 smiths, 20 labourers, and these men were marched to the Control Office, a fortnight's wages issued to them in advance, and each man signed the terms of agreement.

The rates of wages these men engaged for were—

	s.	d.		s.	d.
Foreman carpenter	6	6	..	4	0*
Ordinary „	3	6	..	2	9
Foreman smith	7	6	..	5	0
Ordinary „	3	6	..	3	0
Foreman labourer	—		..	—	
Rigger „	4	0	..	2	0
Ordinary labourer	2	0	..	1	2

An effort was made to induce these men to join without the fortnight's advances of wages, for there really was no power to prevent their running off with the money, but as the men rigidly refused to embark without the advance, it had to be conceded, and, much to their credit, when marched on board the steamer, not one was absent.

The agreement was that wages were to begin from the day of embarkation, at Sierra Leone, to the day of disembarkation on return, a free passage both ways, and rations of $\frac{1}{2}$ lb. of meat and 1 lb. of rice daily.

The stores were examined at Sierra Leone, and the following articles put on board :—

100 3-in. deals,
200 feet, 8-in. by 4-in. scantling,
2 derrick poles,
1 double purchase crab,
1 box of nails,
2 old gyn blocks,
1 coil of 2-in. rope.

An examination of the shops, stores, &c., at Sierra Leone, showed that but little assistance could be expected from that place.

The brass tickets were given to the men by the Commanding Royal Engineer, and they were informed that no pay would be issued unless these tickets were produced.

On the 2nd October the "Ambriz" arrived off Cape Coast Castle. The Commanding Royal Engineer landed at 7 a.m., with the native artisans and labourers, who were at once employed in carrying up the officers' baggage to the various places at which they were quartered.

Rice and salt meat were drawn for the labourers, two basement rooms were obtained for them in the Castle, to sleep in, and a blanket was issued to each man by the Control Department.

The small engineer yard at Cape Coast Castle was found to be filled with the débris of the scarp, which had fallen down, bringing the two 24-pounder guns mounted on the top with it.

The Foreman of Works (native), Mr. Nylander, was directed to clear away as much of the rubbish as possible, and to put on a strong force of men to rebuild the scarp.

* The figures in second column denote the wages these men received at Sierra Leone.

In the afternoon a portion of the huts were brought ashore, and were carried up to the Castle, partly by the Sierra Leone men, partly by carriers obtained from the Control Officer.

It is desirable here to glance at the state of the engineer operations and engineer department generally at this period at Cape Coast Castle.

The Colonial Engineer, Mr. Mercer, who received a sum of £100 per annum from the War Department, took charge of the repairs of the Castle and other War Department property, assisted by a black foreman and black clerk, Messrs. Nylander and Case. Neither Mr. Mercer nor the foreman knew anything of Military Engineering, and thus, as regards the military functions of the corps, there was no person who knew anything about them.

Lieutenant Gordon, of the 98th, was then in the country, and he performed, for some time, the duty of a Military Engineer, examining and reporting on the various roads, constructing redoubts at Abbaye and Napoleon, which prevented the Ashantees coming down to the coast between Elmina and Cape Coast. In this work, Lieutenant Gordon was assisted by a native officer, Lieutenant Smith.

On the completion of the redoubts, Lieutenant Gordon, selecting the best of the workmen employed there, and with about 40 native volunteers, and 15 native police, went to work on the road, cutting it back from Acrowful to Assayboo, and forward from that place towards Dunquah.

Lieutenant Gordon was engaged in this work when the Expedition arrived in the "Ambriz," the road having got as far as Dunquah.

In making this road, Lieutenant Gordon had cut the bush away, removed or cut through the fallen trees, and levelled the roughest places, but the swamps were not corduroyed nor the streams bridged.

Between Assayboo and Cape Coast Castle (9 miles), the Colonial Engineer, at first Mr. Mercer, latterly Captain Crease, R.M.A., was engaged in completing a road, not only clearing it, but draining and bridging the wet places.

Lieutenant Gordon had about 120 men, the Colonial Engineer about 200 men at work.

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3rd October, 1873.—The remainder of the stores from the "Ambriz" were brought ashore, the bundles of wood for the huts were sorted, a site for the range of huts selected, a place selected in the Castle as a treasury vault, and double doors with magazine brass locks, found in the Royal Engineer's store, fixed to it.

Connor's Hill was examined and reported on as a site for an encampment for the head-quarter staff.

4th October, 1873.—At this time much trouble was experienced in dealing with the Sierra Leone artificers. Their object was to do as little work as possible, and each man to get a Fantee to labour under him.

The queer language they spoke, the different meanings they attached to words, and the continued attempts they made to humbug. caused no little difficulty.

This day, the Major General, wishing to have an easel and board, two car-

penters were ordered to make it. These men changed their tickets with two labourers, who wasted a quantity of timber, and, in the end, the C.R.E. made the easel himself.

The place selected for the huts was at the northern gate of the Castle, the ground sloping towards the landing place and along the proposed range of huts. This site was selected because it was then intended to lay in a line of rails to the beach, haul the loads up by the steam sapper to the top of the hill, and break the waggons down the incline close to the doors of the store huts; a wire rope, winding drum, and two miles of light rails had been demanded amongst the articles to accompany the first steam sapper.

The huts were put up 36 feet long, so that two gables were saved. Great difficulty was experienced in getting the framework of the first hut put up. Once it was up, the natives seemed to understand what was meant, and by working them in gangs on the various huts, and giving a small bribe to the gang that got most work done, work began to get on pretty rapidly.

A dry-earth system of latrines had been introduced at Cape Coast some time previously, but failed for want of dry earth. A shed was constructed, and plates of sheet iron found on the beach were used for drying the earth.

Sunday, 5th October, 1873.—The whole of the men were kept at work, and this was always afterwards continued, no difference being made between Sundays and other days. The C.R.E. walked over the country in the neighbourhood of Cape Coast Castle.

6th October, 1873.—Three huts were completed to-day, and handed over to the Deputy Controller. Flooring for several hospital marquees and white officers' tents was made and laid on Connor's Hill. Received instructions from the Major General Commanding to prepare a scheme for the defence of Cape Coast Castle. Furnished this, with a rough sketch, in the evening.

These defences were of the simplest nature; the ground taken up was in advance of the town, and it was proposed to form a small breastwork on the top of each of three hills, thus covering the town from the sea above Moree to Fort Victoria. It was also proposed to cut the bush round these breastworks and between them, so as to open the ground to fire; a gun was to be placed in each.

7th October, 1873.—The whole of the artificers were still kept at work on the huts; one had to be sent to prison for theft, and two had hurt themselves with their tools, and had to be sent to hospital.

The formation of a hospital for natives now became a subject of consideration between the C.R.E. and the Principal Medical Officer.

The Senior Naval Officer, having offered the services of the Navy in landing the steam sapper, after consultation with Lieutenant Adkins, it was decided that it should be landed at high water, parbuckled down 3-in. deals, and left on the sand until the tide fell, and then got on its wheels.

The Major-General directed the proposed scheme of defences to be carried out.

Captain Crease, R.M.A., Acting Colonial Engineer, undertook to carry out the plan, and began work in the evening.

The Major-General, wishing to have a report on the subject of a bridge over the Sweet River, and the state of Elmina, the C.R.E. went to Elmina that evening. A report was furnished to the Major-General Commanding to the effect that, after a careful examination of the country in the neighbourhood of Cape Coast, it appeared that no railway, except one on Mr. Fell's principle, had any prospect of success, and that the gradients in many places were so steep that the steam sapper could not travel (*vide* Appendix VI.)

This opinion about the railway was based partly on the quantity and nature of the labour available.

The low, round, steep hills in the neighbourhood of Cape Coast stand almost invariably in wet, marshy valleys, and at this season these valleys were too wet to deal with; in addition to which, there being no streams, and few water courses near Cape Coast, there was no marked line of country that a railway could follow.

Any line of rails from the coast to Mansu should follow the Valley of the Okee, but the mouth of the Okee was 20 miles to the eastward of Cape Coast Castle.

If, at any future period, a railway in West Africa be attempted, the Valley of the Okee will afford an easy means of getting to Yancomassie-Assin, or within 17 miles of the Prah.

A demand for stores for a telegraph was also submitted (*vide* Appendix VII.)

8th October, 1873.—Examined Elmina and the Sweet River, and reported to the Major-General Commanding as follows:—

The existing defences of Elmina were quite adequate for the purpose; the ground was clear, and the position strong.

A few resolute men in each fort could easily hold the position.

The sanitary state of the Castle, the Hospital, and Barracks was bad. That the room used as a Guard-room should no longer be so used, and that a hut should be built to contain the guard. A hospital marquee might be used to reduce the numbers in the Hospital.

With existing means, a permanent bridge over the Sweet River could be made in three weeks, a temporary bridge in two days, and recommended that a police guard with six canoes should be kept on the river, and the bush cleared on both banks.

Handed seven huts over to the Deputy Controller. Drains were put around the huts to carry off water.

9th October, 1873.—The question of hammocks for the conveyance of sick and wounded was discussed with the Deputy Controller.

A strong party of men was sent to the neighbourhood of Napoleon to cut bamboos for hammock poles and telegraph poles.

The breastworks referred to as being constructed for the defence of Cape Coast Castle were completed, and strong parties put on to cut the bush away.

Lieutenant Bolton, 1st West India Regiment, who had been sent to Accra to collect men, returned with seven carpenters, eight coopers, and three smiths.

After long consultation with the Principal Medical Officer, a memorandum was

submitted to the Major General Commanding, suggesting the engineer arrangements for the future, which were much as follows:—

1st. That the road should be opened.

2nd. That it should be improved, swamps got rid of, and bridges constructed.

3rd. That camping grounds should be selected, and regular camps built at these stations.

4th. That all intrenching tools should be in the possession of the Royal Engineers, and that requisitions for such as were needed should be made on the Engineer Park (*vide* Appendix XI.)

The Major General approved of these suggestions.

10*th October*, 1873.—Captain Buckle, R.E., Lieutenant Bell, R.E., Lieutenant Mann, R.E., and one sergeant, one corporal, and four rank and file, R.E., arrived and landed.

Two of the men were sick and were sent to hospital, the others were formed into a mess, and a black cook detailed for them.

Four additional huts handed over to the Deputy Controller.

11*th October*, 1873.—With the approval of the Major General, appointed Lieutenant Bell, R.E., Adjutant and Park-keeper. Proceeded to Acrowful, and helped Lieutenant Jones, 2nd West India Regiment, in putting the village into a state of defence. Lieutenant Jones, with very small means, had done much to this village.

Two huts were begun as hospitals for natives.

12*th October*, 1873.—Lieutenant Bell, R.E., took up the duties as Park-keeper, collected all the tools that could be obtained in the Colony, and proceeded to sharpen and repair them. (The tools from England not having yet arrived.)

Tools were sent to the various posts—Abbaye, Napoleon, Acrowful, and Elmina; and arrangements were made for hutting the natives, who had come in some numbers from Accra, Palmas, and other places, and who were unable to obtain shelter anywhere.

13*th October*, 1873.—In accordance with the arrangement approved of by the Major General Commanding, the C.R.E. started with 175 labourers for the front, and a large stock of tools. Captain Buckle accompanied the C.R.E. to Batteyan, and received instructions as to taking charge of the road. Two hundred men who were employed by the Colonial Department were handed over to the Royal Engineers. Lieutenant Mann was ordered to make bridges, form side drains, fascine all the wet places, straighten the road where requisite, and not exceed a width of 12 ft. He was also directed to look out for a good site for an encampment between Yamoranza and Inquabim, searching for water for this camp, which, from the wells and watercourse near Yamoranza being much polluted by the police there, should be further up the country than that place.

The ideas of the general arrangements were as follows:—

Advanced party cutting road, Major Home, R.E.; finishing and completing road and making bridges, Lieut. Mann, R.E.; encampments, water supply, and sanitary arrangements, Captain Buckle, R.E.; in charge of Park, Lieut. Bell, R.E. These ideas had to be considerably modified as the work proceeded.

In this, the first march made by the C.R.E. with native labourers, the greatest confusion prevailed. There was no order; men flung down their loads and stopped when they chose, began to cook at all times, and, far from getting into Acrowful at twelve o'clock, the last of the men did not arrive until dark. This was by no means a hopeful beginning.

Mr. Nylander, the black foreman, who accompanied the C.R.E., informed him that the men were determined not to go beyond Dunquah.

The Control labourers were not fed, but received 1s. a day pay. The Major General Commanding had authorized 1½ lb. of rice for each engineer labourer when north of Acrowful, and all men who came into Acrowful late had their rations stopped.

The following day the labourers were turned out at 6 a.m., with great difficulty, many not appearing until 8 a.m. The C.R E. was anxious to improve a short bit of road near Acrowful, and put a bridge over the Achirimasoo river, not only as a convenience to the garrison of Acrowful, but also to try what could be done with the native labourers when there was a guard of the 2nd West India Regiment at hand to enforce obedience.

A note was sent to Lieutenant Gordon, 98th Regiment, then at Wonkorsu, requesting him to meet the C.R E. at Yancomassie-Fantee, the following day.

14*th October*, 1873.—After a most fatiguing day, the swamp, some 30 yards long, was fascined and drained, and a bridge put across the river in four spans of 12 ft. each. This work took 176 men until 6 p.m. The men were determined not to work. The head men of gangs had been selected without any knowledge of the men, and every obstacle was put in the way of doing work. This was anything but cheering, and offered a gloomy prospect for the future.

At 6 p.m. the C.R.E. determined on going on to Dunquah, about six miles, sleeping there that night. The men refused to move; in a body they all determined not to go. Lieutenant Jones, commanding the detachment 2nd West India Regiment, marched a party to the spot, and after some of the ringleaders were flogged, the greater part ran over the bridge and went in the direction of Dunquah, which the C.R.E. reached at 11 p.m.

15*th October*, 1873.—When the men were mustered in the morning, 17 had deserted. The difficulty in handling these men was very great. The Sierra Leone men did not speak Fantee, and the Fantees did not speak English.

At 7 a.m. a start was made, and the C R.E. met Lieutenant Gordon at Yancomassie-Fantee, at 9 a.m. Proceeded with him to Wonkorsu. At this time Lieutenant Gordon was at work on the road between Wonkorsu and Yancomassie-Fantee. He had cut the road, cleared away or cut through the fallen trees, and made the road passable for infantry and such artillery as there was in the country. No bridges had been made, and the swamps were untouched. Lieutenant Gordon had done much, and the C.R.E. reported on what he had done to the Major General as follows:—

"I have now seen the road from Cape Coast here (Yancomassie-Fantee). With the exception of 3½ miles between Yamoranza and Assayboo it is all fairly passable for infantry in fours. I think Gordon deserves great credit for what he has done."

On the arrival of the C.R.E. at Wonkorsu, the men working under Lieutenant Gordon were taken on Imperial pay, and merged in the general Royal Engineer labour lists. It is only fair that testimony should be here borne to the great influence that Lieutenant Gordon had acquired over these men. Of the 120 men he at that time had at work, 83 were paid off at the close of the Expedition. These men, although not so strong or such good axe-men as others turned out to be, were decidedly the best men the Royal Engineers employed. Their head man, Coffee Daddie, proved himself to be most trustworthy; and no little credit is due to Lieutenant Gordon for the skill he showed in selecting these men, and, to a great extent, training them. At the many camps where the Engineers were near Lieutenant Gordon, these men invariably went to see him; and the fact of their steadiness at all times reflects the greatest credit on the power which Lieutenant Gordon possesses of dealing with natives.

On consulting with Lieutenant Gordon, the C.R.E. determined to cut as much of the road as possible towards Mansue, and then push through to that place, and occupy it.

The reasons for doing so were as follows:—

Lieutenant Gordon, who had visited it, reported a large open space covered with Guinea grass, easily cleared, good and plentiful supply of water, and a large quantity of bamboos.

Further, this point, half way to the Prah, was that where the Major General wished to have his main station on the road to the Prah, and, by getting to work on it at once, the road for some miles north and south could be made, and the station built, the whole being superintended by one officer.

16*th October*, 1873.—The road was therefore cut south of Wonkorsu, and as far north as possible.

A messenger sent to the King of Ashantee by the Major General passed through the camp, and returned in the evening. He was made a prisoner, and alarmed the labourers much; two had to be flogged for inciting the others to mutiny.

17*th October*, 1873.—The whole party moved to Mansue, the last three miles of the road being untouched. A camp was formed there, and a large space cleared. The tents of the European officers were pitched under a large India-rubber tree, on the highest point of the ground. The natives' huts were further off, and guards and sentries posted. A small fort was marked out, and preparations made for beginning it the following day.

18*th October*, 1873.—The labourers were divided; one portion to work on the fort, another to clear the bush and cut the Guinea grass. About 10 a.m. a memorandum was received from the Assistant Adjutant General, dated the 16th, directing—

1st. That Lieutenant Gordon should at once proceed to Assayboo and take over the command of the Houssas from Lieutenant Woodgate (Wood's Regiment) and proceed with them to Abracrampa.

2nd. That the C.R.E. should proceed to Abracrampa and place it in a state of defence, and should improve the roads from Abracrampa to Acrowful and Assayboo.

3rd. Informing the C.R.E. that Captain Huyshe had been ordered to proceed to Mansue, taking Abracrampa in the way.

On considering these instructions, the C.R.E. determined to obey them so far as sending Lieutenant Gordon to Abracrampa with a party of labourers and a supply of tools; but he resolved to remain himself at Mansue, for the following reasons:—

1st. The order referred to had been issued in ignorance of the occupation of Mansue.

2nd. Mansue was a place much thought of by the Fantees; its occupation would probably have a good effect, its evacuation would certainly have a bad one, for the moment both the white officers left, the natives left behind would certainly run away and spread terror through the country.

3rd. Lieutenant Gordon had shown much judgment in acting as an Engineer officer, and the C.R.E. believed he could put Abracrampa in a state of defence.

4th. Because the C.R.E. felt sure that, under the circumstances, the Major General would approve his conduct.

Lieutenant Gordon having left Mansue, the fort was proceeded with as rapidly as possible (*vide* Pl. XVII.)

The first step taken was to form a shelter trench. While this was being done, bamboos were cut and brought up. These were planted in the ground and interlaced with split bamboo, and "country rope," or creepers; a large ant-hill in the centre was formed into a sort of keep where twenty men could defend themselves, interior trenches were dug, where the labourers and their women might be concealed.

19*th October*, 1873.—A letter was written to the Assistant Adjutant General detailing the reasons for not leaving Mansue. The fort was pushed on, and in the evening was quite defensible.

About 10 p.m. a letter was received from Captain Godwin, at Dunquah, saying that some of his scouts had lost their heads, and that the Ashantees were believed to be moving on Mansue, and warning the C.R.E. to keep a good look-out. A short time after, Lieutenant Smith, Commanding the Volunteers, reported that he could not rely on his men. They were called up, taken into the fort, and the sentries found by the police.

Towards morning the Police Corporal and two Policemen, left at Yancomassie-Fantee, came up to the palisades of the fort, and reported that the Ashantees had struck the main road at that village. This turned out to be false, but it caused some alarm as the value of native information was not, at that time, thoroughly appreciated.

20*th October*, 1873.—The Police and Volunteers were got under arms at daybreak, and the bush examined. No signs of an enemy being visible, the labourers were put to work, one-half on the fort which was now being fraised, the other on widening the line of retreat to the eastward towards Denkera, and forming a small post in the wood, about a mile and a half from Mansue, to cover, if requisite, the retreat.

A letter was written to the Assistant Adjutant General (*vide* Appendix VIII.)

In the morning, the party sent for provisions the previous day to Acrowful, 21 miles distant, did not arrive. There was now only one day's provisions left. A foraging party was sent out for plantains, and half rations only were issued.

A Native Chief and 40 men came in, armed with flint-locks, but wanting powder and lead. Luckily Lieutenant Gordon had left half a barrel of powder and some lead, and this was issued. Four of the men were specially employed as scouts, and were offered £1 a-piece for Ashantee prisoners; these men remained as scouts through the remainder of the campaign. The rest of the Fantees were encamped on the most exposed point, so as to give notice of any Ashantees that might approach.

A policeman came in, in the afternoon, with the provision carriers, and a letter from Commissary Lundy, saying that he had found some of the bags of rice thrown down on the ground, but had collected them, and sent them on with the carriers, who had slept at Dunquah, and refused to go on.

A copy of the previous order as to Lieutenant Gordon going to Assayboo, and the C.R.E. to Abracrampa arrived; this was directed to Mansue, and was replied to by the C.R.E. (*vide* Appendix IX.)

21*st October*, 1873.—A memorandum signed by Captain Bromhead, as staff officer for Colonel Festing, at Dunquah, was received, informing the C.R.E. that Colonel Festing had taken the command of the advanced posts, giving the names of the European officers at Dunquah, and directing the C.R.E. to fall back on Dunquah, or, if his retreat was cut off, to retire to the eastward.

On receiving this letter, the C.R.E. determined still to remain where he was; the fort was now very strong; there was a good clearing round it; the water supply and provisions were fairly abundant; and if a little ammunition could be got up, the fort was impregnable. Further, in savage warfare, to make a fort and abandon it is really an encouragement to the enemy. The C.R.E. therefore wrote to Colonel Festing, informing him of the real state of affairs, of which he was ignorant, and asking to be supplied with ammunition and food; and, further, pointed out that if the Ashantees were to debouch at Yancoomassie-Fantee or Wonkorsu, as was then expected, and as subsequently they tried to do, the position of Mansue was too important to be abandoned.

The scouts brought in two Ashantee prisoners, a man and a woman. The man declared he was a slave, and had fled because he was about to be sacrificed. The Fantee Chief, who had joined the C.R.E., declared that this was a falsehood, as he had the marks of a free Ashantee. A cup of rum was given to him, and under its influence he stated that he had been sent to see if the white man had got to Mansue. The fort was completed, and a storehouse begun in it (*vide* Pl. XVII).

22*nd October*, 1873.—Ammunition and food arrived from the rear, also a letter from the Assistant Adjutant General, informing the C.R.E. that his proceedings had been approved by the Major General. There were heavy rains, which effectually prevented the burning of the large quantity of cut bush, and stopped work generally. Sergeant Rockhead, R.E., arrived, and took up the

duties of issuer, which had previously been performed by the C.R.E., a duty he could not properly perform, and many irregularities were the result.

23*rd October*, 1873.—Work was resumed on the road south of Mansue, still left uncut since its first occupation on the 17th, and the ground in front of the fort cleared, and got ready for buildings.

Letter received from Lieutenant Bell, reporting his arrival with a quantity of tools at Dunquah; also from Captain Huyshe, Deputy Assistant Quartermaster General, reporting that he would arrive the following day with a party of Houssas.

24*th October*, 1873.—Work as yesterday. Captain Huyshe, 25 rank and file of the Houssa Company; Lieutenant Bell, R.E., with a convoy of tools; and Lieutenant Hearle, R.M.L.I., with 100 Assims, arrived. The Houssas were encamped, and given tools to hut themselves. The Assims were also encamped.

The general idea of the station at Mansue, with the general position of the various buildings, was pointed out to Lieutenant Bell, R.E., who was directed to form a park of tools at Mansue, and to push on the buildings as rapidly as possible.

The C.R.E. returned to Dunquah. On this return journey it was found that the roads had been much overgrown, but were still fairly passable.

At Dunquah, the C.R.E. found that Captain Huyshe had made a very good redoubt of the fragments of the mud walls of the houses; that Colonel Festing had done much in the way of clearing. The C.R.E. advised the addition of a line of fraises round the work, and he put a wire entanglement on the most exposed salients.

26*th October*, 1873.—The C.R.E. proceeded to Abracrampa, and found that Captain Huyshe and Lieutenant Gordon had strengthened the place, and, in his opinion, it was sufficiently strong to resist attack, but the bush round it required much cutting. Lieutenant Pollard, R.N., in charge of the Abrah tribe, set to work this afternoon to cut away the bush.

27*th October*, 1873.—The C.R.E. proceeded to Battyan, to see Lieutenant Mann, R.E. He found that officer ill with fever, and the non-commissioned officer, Lance Sergeant Masters, laid up with dysentery. The road from Cape Coast to Battyan had now been completed by Lieutenant Mann, and was in excellent order.

The C.R.E. directed Lieutenant Mann to remove to Acrowful that evening with the head-quarters of his party, in order that he might be in a more healthy position, and have the benefit of medical advice.

While walking over the road towards Cape Coast, the C.R.E. met a party of seamen and marines proceeding towards Abracrampa from Assayboo, and he learned that the Major General had gone there. As the road was blocked with men and stores, the C.R.E. returned to Acrowful, and proceeded thence to Abracrampa, where he met the General. He gave him a report on various points (*vide* Appendix X).

28*th October*, 1873.—The C.R.E. taking charge of an axe and cutlass party, composed partly of Kroomen of the Navy and partly of the workmen taken

down by Lieutenant Gordon, accompanied the General in his reconnaissance to Assanchi. No work was required; the detachment returned to Abracrampa.

29*th October*, 1873.—The Major General directed that the C.R.E. should make arrangements for having water for the seamen and marines at Assayboo, by means of water carts, and further that the tents should be pitched for them. The water carts were therefore sent from Assayboo to Acrowful to get water, being drawn by the Chiefs of Assayboo and pressed men. The tents were pitched by 100 engineer labourers taken off the road. The C.R.E. returned to Cape Coast Castle.

30*th October*, 1873.—On the return of the Major General to Cape Coast Castle, he expressed a wish that the defences of Abracrampa should be strengthened, and Captain Buckle, R.E., was directed to go there. He took a small party of men and some tools. Much work had been done by Captain Buckle during the C.R.E.'s absence.

The following is from Captain Buckle's Journal, and details the Engineer operations at Cape Coast Castle during the C.R.E.'s absence at Mansue:—

13*th October*, 1873.—Huts behind Prospect House for Russell's Regiment were begun. Captain Crease, R.M.A., Acting Colonial Engineer, having left for the Volta, Captain Buckle took up his duties, which were chiefly connected with the water supply at Cape Coast.

14*th and* 15*th October*, 1873.—Nothing of importance took place on the former. To-day the first addition to Lieutenant Mann's party, 1 foreman and 27 men, with a proportion of tools, started at 7 a.m.

Four huts for Russell's Regiment completed in front of Prospect House. 66 men arrived for that regiment. The framework and boarding of one side of one of the two huts for the hospital is fixed.

Received authority from the Major General to purchase umbrellas for the Royal Engineers and any other stores that may be required.

The labourers hired at Sierra Leone, and working under the Royal Engineers, who hitherto have been receiving subsistence money at 9d. a day, to-day received their rations in kind, and, in consequence, there was a good deal of grumbling and some difficulty in getting them to work. Arrangements must be made for the men of the Native Engineer Company to receive their rations in kind, as the present system of subsistence money and pay causes confusion, and gives a great deal of extra labour in accounts.

Of the huts sent out from England, there are now erected and ready for occupation, Control Store Huts, 18; Engineer Store, 2. Bamboos are being brought in as fast as possible; there are now 200.

The want of a good clerk for the Royal Engineer Office is much felt; one should be asked for as soon as possible.

Summary of progress sent to the Chief of the Staff.

16*th October*, 1873.—The Major General, in reply to the C.R.E., thinks that the rates of working pay proposed should not be issued till instructions are received from England; also, that shoes be issued to the men in lieu of boots, and boots be demanded from England. Letter to Deputy Adjutant General in accordance with above.

19th October, 1873.—The Royal Engineer smiths' shop has now been completed. The framework of a bamboo shed for a carpenters' shop is fixed. The bamboo framework of the shed for Control labourers in the old building on the sea wall is fixed; one-third of it is thatched with Guinea grass. Extra accommodation will also be provided by fixing a lean-to along the sea wall, and thatching in the same way as above with grass, so as to contain the large number of natives imported from Sierra Leone, Palmas, and elsewhere.

Major Home, C.R.E., has been ordered to Abracrampa to fortify that post, and Lieutenant Bell, R.E., to proceed to Mansue forthwith.

Recommended the purchase of two iron tanks of 350 and 550 gallons, to hold condensed water, as one of the Castle tanks leak. It has been decided that each Royal Engineer Officer is to have with him a depot of tools, from which he is to supply the demands from officers in command at outposts (*vide* G.O.II. of the 17th instant, Appendix XI.)

The hutting at Prospect House for Russell's regiment, completed on the 18th.

Went up on the 17th to Assayboo, to visit Lieutenant Mann's party. Found that the road was progressing, but that the parties under him were too scattered. It is of importance that working parties should be close together, so that supervision can be exercised over all without an officer exhausting himself in walking between the different parties; the labour of walking in the heat of the sun is very great, and thereby tends to make an officer slur his work when he arrives at his ground.*

The parties being so scattered is not the fault of Lieutenant Mann, as the work and the workmen were only taken over from the colony on the 15th, and he is now merely finishing work that had been left undone, the parties having been pushed on without entirely completing their work. Two of Lieutenant Mann's gangs are now beyond Assayboo, between that place and Battyan. I found that between these two places there is about fifty yards of swamp, which will require to be fascined.

I ordered Lieutenant Mann to move his quarters from Assayboo to Battyan as soon as he had completed all the road to 12 feet in width, as ordered by the C.R.E., up to Assayboo, and he expects to be there about the 21st.

Acting Sergeant Masters, R.E., is with him, and they are both well. I also ordered him to arrange, if possible, the working hours of the labourers, as follows:—From 6 a.m. to 10 a.m.; and from 1 p.m. to dark (about 5.15 p.m); the men to dine in the middle of the day.

It should be explained here that the working party is divided into gangs of

* This difficulty was always found; the officer not being mounted, very great labour had to be undergone to keep the men at work. But to work the road rapidly it was found, as the result of much experience, that 200 men a mile were as many as could profitably be employed, and this number was divided into several gangs. The leading gang armed with cutlasses and small hatchets to clear the bush; the next gang with axes to cut through the fallen trees and stub up the roots, which would otherwise have cut the boots of the Europeans; the third gang with pickaxes and shovels, to make good; and lastly, the bridging party. All these men could thus work together at one time.—R.H.

25, each under its own headman, who receives the pay for it, is responsible for it, and that the road is made according to orders.*

Whilst out with Lieutenant Mann on the 18th, looking over sites for camping grounds that he had selected, we met Captain Huyshe, Deputy Assistant Quartermaster General, who approved of one of them on the east side of the road, opposite the little village of Inquebim, close to a burnt palm tree, which is a most conspicuous landmark for it. The ground is cleared garden land, with plenty of palms for the huts to be erected there; water quite close, and I hope in plenty, at some little distance below the surface, but quite easily procurable by one of Norton's tube wells.†

When the C.R.E. arrives, I hope to commence hutting there at once. It is distant about eight miles from Cape Coast.

21*st October*, 1873.—The undermentioned men are appointed acting sergeants from this date, viz. :—Corporal C. Page; Lance Corporals A. Annetts, J. Roberts, T. Webb, W. Barthorpe; Sappers G. Pack, S. Hatherley.

26*th October*, 1873.—Lieutenant Bell started on Wednesday, the 22nd, for Mansue, to relieve the C.R.E. He took with him a number of entrenching and other tools to form a depôt at Mansue.

On the 25th, on the recommendation of the principal medical officer, Sergeant Dickson was sent to Dunquah with one Norton tube well pump, and a second one for Mansue.‡ He is to remain at the latter place after having fixed the one at Dunquah. These pumps have been borrowed from the Colonial Engineer.

Sergeant Pack was sent to Lieutenant Mann, so that he has now two sergeants to assist him. Lieutenant Mann reports, under date of the 24th, that the road is finished between Yamoranza and Assayboo, and that he hopes to have it finished to Battyan by the 29th, where his quarters will be on the 25th, four days after the time he expected (*see* 19th).

Have had a truss girder put together to show the workmen how to do it, and am only waiting transport to send these and the trestles ordered by the C.R.E. which have been ready two days.

The machinery of the steam saw, &c., landing; meanwhile have had the bench for circular saw commenced.

Finished 45 hammocks and cots.§ Awning frames made from surplus doors, with a barrack sheet nailed on them, and they were sent with the Marines and sailors that accompanied the Major General to day to Dunquah.

The two huts for hospital are completed, and two more are now in course of erection as medical stores close to these, of which one is two-thirds done. A temporary latrine is also being made for the two hospital huts, of bamboo framework and wattling.

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* This had to be subsequently discontinued, as the Headmen stole the money.

† This site was altered subsequently by the Major General, at the request of the C.R.E., to one about half a mile nearer Cape Coast Castle, on the west side of the road.—R.H.

‡ These wells were never of any use.—R.H.

§ Hundreds of these hammocks were fitted up with poles, cross-beams, awning frames, and awnings, for the use of the hospitals.

27*th October*, 1873.—To day safely landed the boiler of the steam sapper. It was beached in the surf boat, and the boat with the boiler in it then hauled by labourers above high water mark; the boat was then turned over and the boiler rolled out, preventer ropes held by labourers keeping it from rolling out suddenly.

The huts still going on; the uprights and rafters for a shed to enlarge the carpenter's shop in the Royal Engineer park are now fixed, and the wattling has just been commenced. The boiler of the steam sapper has been placed on its wheels.

The bakery is in good order; both ovens now at work. The flues of both had to be altered.

28*th October*, 1873.—Wrote to Colonel on Staff to authorise detention of half Bickford's fuze sent out for Glover's expedition, as there is none here. Huts and hammocks going on. Twenty-six casks (36-gallon) arrived from Elmina to be converted into filters; commenced these at once. The two tanks for the reception of condensed water nearly ready *; have been whitewashed inside, and are to be done outside also. One of the waggons for the traction engine put together. Forty-two huts are completed; six more in hand.

The kitchen asked for by the principal medical officer, on Connor's Hill, of wattle and thatch, is erected, and the addition to the hospital for latrines is in hand.

I heard to day from Captain Peel, R.N., Her Majesty ship Simoom, sent to take command of the garrison, that he left the C.R.E. with the Major General at Abracrampa on the 27th instant.

From Office Journal.

31*st October*, 1873.—Steamed up the hill and through the town with the steam sapper, to the intense astonishment of the natives. Got the saw bench to work and began sawing timber; completed the last of the huts, and handed over to the Controller the keys. Arranged to go up to Acrowful on Sunday. C.R.E. wrote to the Chief of the Staff representing the necessity for additional labour on the roads and elsewhere (*vide* Appendix XII.); also the necessity of calling in from out stations the entrenching tools, of which a large number are out. Issued fifty cutlasses as weapons to the Kossoos. Hospital huts nearly completed. Sanitary officer ordered up to inspect camping grounds.

1*st November*, 1873.—Worked the engine sawing in the morning; in the afternoon was ordered to take an Ashantee prisoner on the engine some two miles out of the town. The engine did not work at all well; her boiler primed, she got short of water, and refused to go up a hill. Altogether, it was not a successful trip. On returning, the engine melted the lead plug in the boiler, and blew out. The plug was replaced, and we returned to Cape Coast Castle about 8 p.m. As was expected, the hills are too steep to allow of an engine working along the road.

* *Vide* 19th October, 1873. These tanks were subsequently of great value.

2nd November, 1873.—Went to Acrowful, taking a party of 10 carpenters, 25 labourers, and Sergeant Barthorpe. Found Sergeant Masters very ill; Lieutenant Mann and Sergeant Pack both ill. Gave some directions about the road. Found that the whole party of men had bolted from the road and would not work on Sunday. Directed a magazine to be made, and also the ground to be cleared round the little village, and huts for store huts begun; other huts to be cleared out and roofed over. Lieutenant Mann has now trestles for bridging the streams, and plenty of bamboos; but his health is very bad, and so many of his sergeants are suffering, that much cannot be done. Lieutenant Mann's party should be double its present strength.

3rd November, 1873.—The traction engine hauled up two of Crease's filters, weighing each two tons, from the beach. It also sawed a good deal of timber, and hauled water from the condenser. The Major General directed a post to be formed at Assayboo, to cover the Abracrampa, Assayboo, and the Assayboo-Battyan road; this post to hold fifty white men and a gun. Directed Captain Buckle, R.E., who had reported the works at Abracrampa as complete, to proceed from Abracrampa to Assayboo for this purpose, and take with him 30 Engineer labourers from the former place. Captain Buckle had, unfortunately, left Abracrampa before this letter arrived. He returned to Cape Coast, and goes to-morrow to Assayboo. Wrote to the Inspector General of Fortifications on the subject of the railway, also on the subject of additional officers for service here. Arranged for 25 Royal Engineer carpenters and labourers and 25 Control men going to Mansue, Sergeant Roberts to accompany them and hand over charge at Dunquah to Sergeant Dickson, who will take them on to Mansue.

4th November, 1873.—Started the party for Mansue at 6 a.m, with Sergeant Roberts. Two iron surf boats sent out from England in pieces, with drawings, and bolts for fitting, were handed over to the Royal Engineer Department to be put together. One of the end pieces of the 50 ft. boat had been dropped overboard when landing, so the 40 ft. boat only could be put together. Applied to the Royal Navy for three working fitters to put the boat together. Detailed all the carpenters to assist in putting together this boat for the Control Department, for want of other labourers. The natives to work under the naval fitters.

The engine sawing timber. Wishing her to haul in the afternoon, found two of her tubes leaking, and had to desist. The behaviour of this engine has caused much disappointment. Captain Buckle went to Assayboo to form a post in the afternoon, with orders to press the men in the village to work. Lieutenant Mann ordered to send him 30 workmen from Acrowful. Hospital store huts being floored with 1 in. timber cut up by the engine, from 3 in. deals bought at Sierra Leone.

5th November, 1873.—Directed two additional huts to be put up for the Control Department. Prepared a quantity of tools to go to the front.

6th November, 1873.—Intelligence having reached Cape Coast that the entrenched village of Abracrampa has been attacked during the night by the Ashantees, proceeded to that place with the Major General Commanding. Found

Assayboo placed in a state of defence by Captain Buckle. Reached Abracrampa about 5.30 p.m. At the Major General's desire, examined the works, and reported that they were ample for the purpose intended. Captain Buckle had placed the village in a perfectly defensible state, improving on the work begun by Captain Huyshe and Lieutenant Gordon. In this country the truest defence is clear ground; and a very small weak post with a large space of cleared ground is much more efficient than a large strong post with a small extent of cleared ground. Sent to Acrowful for 30 sets of entrenching tools, and formed a few additional defences where it seemed desirable.

7*th November*, 1873.—Ashantees retreated in the forenoon and were pursued by natives. Left some tools with Major Russell to bury the dead and to burn all the bush, &c.

8*th November*, 1873.—Started from Abracrampa at 4 a.m. Went to Acrowful. Found Lieutenant Mann still very weak, and two out of three of the sergeants in hospital. Captain Crease, R.M.A., having kindly volunteered to look after the work, is pushing it on well. A good magazine has been built, good store constructed, and native huts at the small village cleared out and roofed for stores; a good deal of ground cleared, and the road pushed three miles towards Dunquah. Gave instructions to clear more bush; begin hutting for troops and forming encampment. Returned *via* Assayboo to Cape Coast, accompanied by Captain Buckle, R.E., to whom the new site of the Inquabim encampment was pointed out.

9*th November*, 1873.—Began work on five new huts for the Control Department; prepared loads for 100 men to go to Mansue; succeeded in getting 50 loads sent to the front, including portable forge and coal, entrenching and cutting tools. Engine employed sawing timber. Boat for the Control Department ready for launching. A letter written to Colonel Festing, requesting him to send 300 men to Mansue from Dunquah.

10*th November*, 1873.—Huts being proceeded with. Fowke's pontoons, two rafts, and one raft of Blanshard's, 30 bags of coal, the trussed girders (12 and one spare), and some entrenching tools sent to the front to Mansue.

From Captain Buckle's Journal.

11*th November*, 1873.—The C.R.E. left for the front. Wrote to Senior Naval Officer, asking him to take charge of and launch the 40 ft. surf boat, which is now ready. Twenty labourers sent with C.R.E. to Inquabim to commence preparing the site for the first encampment there. At the request of the Officer Commanding Royal Artillery, commenced some alterations to carriage of one of the 4½ in. howitzers to adapt it for a Gatling gun. One more hut completed.

Reply from Senior Naval Officer—Not advisable to launch the boat.

12*th November*, 1873.—Party still at work at Inquabim preparing site for first encampment. The three fresh huts, 22 to 24, still going on. Received orders about a stable at Connor's Hill; sent the wood for it. Sergeant Masters returned to-day from Acrowful, very ill, and was sent on board the Simoom.

Sent up 9 loads of picks and shovels to Mansue. Cannot obtain sufficient transport for the carriage of Engineer stores to the front.

The strength of the Native Engineer Company is now 150, and of the labourers about 150 here, and at Mansue and Acrowful.

13*th November*, 1873.—Heard from the C.R.E., who is not satisfied at the progress of the road at Dunquah, or of the mode of building the encampment at Acrowful. Huts going on; two more commenced above Engineer Office; nothing of importance. Sapper Hatherley admitted on board the Simoom; this is the third of the six men landed here on the 10th.

14*th November*, 1873.—Sent a party to encamp at Inquabim, under Sergeant Page, to commence the encampment. The Sergeant Major (Dunne) left for Mansue.

16*th November*, 1873.—Huts opposite the gateway of the Castle completed, numbered up to 24; those at Royal Engineer Office half done.

I went up to Acrowful on the 15th, and there met the C.R.E., who then decided that Lieut. Mann's party should keep at work on the road, and that the party in rear, now working at the encampment at Inquabim, should complete that at Acrowful afterwards, and ordered a gang, 35 strong, from Lieut. Mann's party to Inquabim. On the return from Acrowful met a large party of about 150 carrying Royal Engineer stores to C.R.E., Mansue. Amongst them one Blanshard's pontoon, gun-cotton, trestles, &c.

19*th November*, 1873.—On the 17th a party of 145 Moree, who had been disarmed for cowardice, were sent from Assayboo for employment as Royal Engineer labourers.

On the 18th started with one of the Crease's filters and 80 of these Moree men, and the steam sapper from Cape Coast, and arrived nearly at Yamoransa at dark, about 5 miles. It was necessary on two occasions to haul the steam sapper itself up the hills, and often to put on the 80 men as well as the steam sapper to haul the tender up the hills. In future it will be less labour to drag the filter on a truck purposely constructed for it, by manual labour alone.

21*st November*, 1873.—Huts 25 and 26 completed, and handed over to Control Department. Truck in course of preparation for conveyance of a Crease filter up country. Six more trestles 7 feet high being constructed to send up country. Inquabim going on.

23*rd November*, 1873.—Went out to Inquabim; found one hut framed, three-quarter roofed; one hut framed only; four others just marked out with poles. Laid out the officers' huts, guard room, Control stores, latrines, and cook-houses. Made a sketch plan of place, which sent to C.R.E. Huts 27 and 28 completed, and handed over to the Control.

24*th November*, 1873.—Began spare poles for bullock draught for Rait's Artillery; also yokes.

25*th November*, 1873.—Bought 151 pickaxes and 135 spades and shovels, according to the orders of the C.R.E.; also bought some ordinary country rope for ties in the building of the huts at Inquabim. The C.R.E. also ordered me to buy some matchetts (country knives).

26*th November*, 1873.—151 picks, 147 shovels and spades, and 200 knives have been received accordingly from Mr. Barnes and Mr. Sarbah. Huts 29 and 30 completed.

27*th November*, 1873.—Steam sapper started with the second Crease filter for Acrowful; a party of 23 more Moree men joined, who, with 50 sent from Sergeant Page's, will be able to take it along the road.

Visited Inquabim; found—

2 soldiers' huts roofed.
1 „ „ roofing.
1 „ „ wattling commenced.
Guard room wattled; half roof on.
Control store framework half done.
4 Officers' huts framed.
Well sunk to 10 feet deep and enlarged.

Found that the Crease filter had arrived safely there, and that 50 men were sufficient to move it along the road. Despatched 54 shovels and 54 picks to the C.R.E.; also 200 matchetts. Received orders to floor six hospital marquees on Connor's Hill; I shall be able to do three with the flooring already there, including that at present used in the tents of officers of the West India Regiment, (who are going to move,) supplemented by a little new stuff; but not six.

28*th November*, 1873.—The second filter has arrived safely at Battyan. Stable at Connor's Hill going on, also the flooring of three hospital marquees; nothing else of consequence.

29*th November*, 1873.—Wrote to Major Brownwell, the Civil Commandant at Saltponds, asking him to purchase mats, knives, and rope there, or at Anamaboo.

4*th December*, 1873.—Accompanied the Major General on the 1st to Yancomassie, returning to Cape Coast on the evening of the 3rd. With him I visited the camps at Inquabim and Acrowful. At Inquabim it was decided to use canvas for the walls of the huts, if procurable from Royal Navy. At Acrowful it was decided, with the concurrence of the Principal Medical Officer, to utilise the present officers' mess and hospital* as the hospital for the station, the houses at the encampment to be used as officers' quarters, Control store, and guard room. Most of the huts there are falling down.

I went on to Yancomassie, and laid out the camp there on the 2nd inst., leaving Sergeant Annetts in charge, and 221 Elmina men with tools, &c., to go on with it. I also sent out a Control store hut for this encampment. The filter for Acrowful had only got as far as Battyan.

Of 34 men sent to Acrowful on 30th ult., only 5 were left on the morning of the 3rd, the whole of the others having deserted. I reported this to the Colonel on the Staff this day. Received orders from the C.R.E. to obtain 2,000 bamboos for telegraph poles, and a notification that 12 ship carpenters were to be attached to the Royal Engineers from the Royal Navy. Commenced the alteration of the second waggon for the steam sapper, to carry the third and last Crease filter as far as Yancomassie.

* The Mission House and Church.

5th December, 1873.—12 carpenters Royal Navy landed, and attached to Royal Engineers, to help superintending the workmen on the road.

6th December, 1873.—7 of the above were dispatched this morning as follows:

To Sutah—Carpenter's Mate	W. Hanson.
„ Crew	T. Cooper, R. Windsor.
To Mansue—Carpenter's Mate	T. Salter.
„ Crew	T. Richards.
To Kinnarsu—Caulker's Mate	T. Llewellyn.
Shipwright	T. Parminter.
Leaving at Cape Coast—Caulker	R. Netherway.
Carpenter's Mate ..	W. Weeks.
Shipwright ..	T. Short.
„ ..	T. Osborne.
Carpenter's Crew ..	T. Hawse.

8th, 9th, and 10th December, 1873.—Absent up the road inspecting the camps at Inquabim, Acrowful, and Yancomassie. At Acrowful, with Principal Medical Officer, decided on what was to be done for the conversion of the church and mission house into a hospital.

The church will be fitted with horizontal bars, supported by uprights driven into the ground, at a height of 3 ft. 9 in. from the ground, to take the poles of the cots and hammocks, so that the sick and wounded may be brought into the hospital and will sleep in their hammocks. Both buildings are to be cleaned and whitewashed, and screens of some kind provided for the windows.

On returning to Cape Coast on 10th, found H.M.S. Himalaya with the 28th Company Royal Engineers on board, the following officers with the Company: —Captain R. O. Jones, Lieut. Jekyll, Lieut. Skinner, Lieut. Cotter, and Dr. Murphy.

11th December, 1873.—The Major General did not wish the men of the Company to be expended on this side of the Prah, so that it was at last decided to land a few only to aid in superintendence, and a portion of the telegraphists, so as to commence laying the wire at once.

For the road—Lieut. Skinner and 5 non-commissioned officers and sappers.

For the telegraph—Lieut. Jekyll and 15 non-commissioned officers and sappers.

12th December, 1874.—The details as above landed. Lieut. Jekyll was at once dispatched to Beulah to examine and buy, if suitable, some bamboos that had already been cut for poles. The poles were good, and he bought 1,496 at 2d. each.

Lieutenant Skinner and party were sent on to the front, with orders to halt at Mansue, to await distribution by the C.R.E.

15th and 16th December.—Went up to inspect the camps at Inquabim, Acrowful, and Yancomassie. The party had left Inquabim, which is now complete, except the surgery.

At Acrowful I found that the officers' quarters were all complete. Guard-room and Control stores also complete. Filter fixed. The six soldiers' huts were about half done. The church had been cleaned out, and was being white-washed.

At Yancomassie the huts were half done; Control Store completed; 2 officers' huts (of timber) were completed, except wattling the sides, and the Crease filter had arrived.

A small wooden hut for a surgery for this encampment, and another for Inquabim, are now ready, waiting removal from Cape Coast.

17*th December*, 1874.—Received orders from the C.R.E. to send up as many Royal Engineer stores as possible, and to divert the canvas from use at Acrowful and Yancomassie to the Prah. Telegraph is now laid for two miles from Cape Coast.

18*th December*, 1874.—One hundred loads of picks and shovels, blocks, ropes, &c., sent to C.R.E., Mansue, to be forwarded to the front. Orders sent to Sergeants Loxton and Annetts not to use the canvas at Acrowful and Yancomassie, but take it on with them when they go to the front.

From the Commanding Royal Engineer's Journal.

11*th November*, 1873.—The C.R.E. proceeded to the front, taking with him 50 labourers. He marked out the encampment at Inquabim, and left 25 men there to clear the ground, which was on a gentle slope, and well situated. On arriving at Acrowful, the C.R.E. found Lieutenant Mann, R.E., still very feeble, and Sergeant Masters so unwell that he directed his being sent to the coast at once.

12*th November*, 1873.—The road between Acrowful and Dunquah, a distance of about two miles, was at this time being made by Captain Crease, R.M.A., who did good work; Sergeant Barthorpe, R.E., worked well also under him. The road between Acrowful and Dunquah has many bad spots and streams on it; a good many were bridged. Directed a clearing to be made for the Acrowful camp; slept at Dunquah. Found the road near that place much blocked by trees and branches cut by the natives.

13*th November*, 1873.—Arrived at Mansue. The continued rains have made many portions of the road very bad, the constant traffic of carriers to the front in heavy rain on the road before it had been well dried, churning the clay up into mud; in several places it was almost knee-deep; the worst places being between Wonkarsue and Mansue. At Mansue, Lieutenant Bell, R.E., had done a great deal of work. The European lines were nearly completed, nearly the whole of the hospital was completed, the natives' lines and labourers' huts in good order, large clearings made, and the sanitary state of the place in good order. Pl. XX. shows the cantonment at Mansue. The huts were built 70 ft. long, 7 ft. to the eaves, and 17 ft. wide. At the other stations, the height of the huts was limited to 6 ft. to the eaves; at the Prahsue encampment, 5 ft. to the eaves. The method of making these huts was as follows:—A framework of bamboos was formed, uprights placed every 5 ft. to carry the rafters, which were supported by centre bamboos (*vide* Pl. XVIII.) or forked sticks. The whole of the plates, ridge pole, and rafters, were lashed together with creepers, and a solid framework thus formed; indeed, it was extraordinary how strong the

framing of the hut so made became. While the hut was being framed, a number of bamboos cut to the proper length—*i.e.*, the height of the eaves from the ground—were prepared. They were struck repeatedly at the knots with a sharp hand hatchet, until the bamboo (almost all the bamboos used were female bamboos) opened and unrolled, becoming in fact a bamboo plank. This was forced in between the plates of the wall. Each bamboo unrolled to about 14 in. wide, and a succession of the 14 in. planks formed the walls of the hut. The roof was formed by getting the palm leaves, stripping them off the central stem, and tying them with creepers to a light framework; this was pulled up to the ridge piece, and lashed to the eaves and the ridge, the whole being finished by filling in the space with dry plantain leaves, and a capping of thatch made on purpose. It will be seen that, by a proper division of labour, work could be done very quickly. The operation of building a hut was usually as follows—

The four corners were marked out by a European, at right angles, a piece of creeper stretched from corner to corner, and the ground marked, the places for the uprights fixed, and a dozen natives put to make the holes, which they usually did by sitting on the ground, and working with a cutlass or knife or the head of a pick axe. While this was being done, parties were at work cutting and fetching bamboos, "rope" (*i.e.* creepers) and thatch. As the bamboos came in they were picked, the best selected, and cut into lengths for the walls, split, and unrolled. Thus a very large number of men, sometimes 150, could be employed on one hut, and by such means rapid progress was made. Guard beds were formed in each hut down the sides. These were of split bamboo, with the round sides up, supported on longitudinal bearers, which ran the whole length of the hut. These guard beds had some spring, and with a blanket were far from uncomfortable. Windows were made for ventilation, about four on each side, and the ends of the huts under the eaves left open. Along the wall, where the men's heads came as they laid down, a second planking of bamboos was put for 2 ft., so as to give an extra protection to the men's heads from the cold winds. Drains were dug round the hut outside. The floors of clay were at the large stations, and in the hospitals, raised a foot above the ground outside, and well beaten down, fires being lighted on them, and the wood ashes beaten into the clay. Mansue was always very wet and damp, and officers, although two were in a hut 14 ft. by 8 ft., generally went to bed with a fire in the centre of the hut. The hospitals were somewhat similar, the bamboo being further thickened by a palm thatch down the sides, so as to keep out the air, and the beds were made with spaces 3 ft. wide between them, so that the doctors might visit the patients. Shelves were put up in each ward; a small covered passage being usually made to a little detached hut, where the night stools and washing apparatus were kept, one of these detached huts being provided for every two wards. An officer's ward, a contagious disease ward, and a hospital store, completed the hospital. Further, a large number of mats were obtained and used to line the walls, cover the ventilators at night, and also the open spaces at the end of the huts, under the eaves. These mats could be removed at pleasure. Mats over the doorways prevented too great a draft (*vide* Pl. XX.)

The whole of these arrangements were made in conjunction with the principal medical officer, Sir Anthony Home, K.C.B., V.C., who gave the C.R.E. the greatest assistance in every way, both by his valuable advice, and also the care he took to make all requisitions in good time, and to meet the difficulties the Engineers laboured under in every way.

Lieutenant Bell had, by the time the C.R.E. arrived, done not only a great amount of work, but he had got the labourers into shape and under control.

14th November, 1873.—Went with Lieutenant Bell to inspect the bridge he had put across the Okee river. This bridge is shown (*see* Pl. XIX.)

The Okee rose 2 ft. 6 in. in the night, owing to the heavy rains. The road had been cut by Lieutenant Bell from Mansue to the Okee, and from thence to Dadiasue, about four miles from Mansue. The C.R.E. ordered the acting sergeant major Dunne, who had suffered from fever at Cape Coast Castle, but was now better, up to Mansue, thinking the change would do him good.

15th November, 1873.—Selected site for ovens and bakehouse at Mansue. Received letter from Adjutant General to the effect that the Denkera tribe, then about 500 strong, was to be attached to the Royal Engineers for work. This tribe had attached to it Lieutenant Hearle, R.M.L.I., as Commissioner, and this officer, who had already done much work for the Royal Engineers, from that time acted as assistant engineer. The Okee having further risen, the bridge was inspected, and found, although the total rise was now 5 ft. 6 in., to be in good order.

The camping stations in rear of Mansue, viz.: Inquabim, Acrowful, and Yancomassie-Fantee, having been determined on, it was desirable to fix, approximately, on the next place to the north. For this reason the sanitary officer, Dr. Gore, and the C.R.E. made a reconnaissance to Sutah, which had not yet been visited. The road was found to be very bad in some places, but the crooms between were good.

16th November, 1873.—Having considered the whole state of the Engineer works, the time and labour available, the C R.E. determined to make an alteration. Instead of cutting the road and following up the cut road by a party bridging and forming the road, he determined to cut and make the road at one time, and to employ separate parties on each encampment. Being desirous to inspect the progress of the Acrowful and Inquabim encampments, and also the road to Dunquah, the C.R.E. determined to go down the road, and communicate with both Lieutenant Mann and Captain Buckle. Having started at three a.m., he reached Yancomassie-Fantee at twelve, and found an immense body of native allies encamped on the ground for the European encampment, in direct violation of orders. The evils caused by natives encamping on the ground selected for Europeans was not only the fact of their fouling the ground, but also that the hutting material in the neighbourhood was cut and destroyed. On reaching Dunquah, the C.R.E. reported to Colonel Festing what had occurred, and found that the allies had encamped on this ground in direct opposition to his orders. Colonel Festing started with a body of police to make them strike camp, and set the whole on fire.

The C.R.E. found the road had got to within a mile of Dunquah, and that something had been done, but very little, to the Acrowful encampment. He therefore directed Lieutenant Mann to work only at the road, push it on as rapidly as possible, reducing its width to ten feet, and informed him that so soon as he could get on to Dadiasue, four miles north of Mansue, he would at once move to the front.

Captain Buckle reported good work being done at Inquabim by Sergeant Page. The C.R.E. requested him to form a party of 180 to 200 men, under Sergeant Loxton, to build the Acrowful camp, and a further party of 200 men, under Sergeant Annetts, for the Yancomassie-Fantee camp. He further requested Captain Buckle to take the superintendence of the work up to Yancomassie-Fantee, the C.R.E. taking it on from that point. The C.R.E. returned to Dunquah that night.

17*th November*, 1873.—The C.R.E. returned to Mansue, and on his way found an Ashantee slave on the road; labourers running away and in great terror, because the Ashantees had touched the main road near Wonkorsue. Returning to Mansue with Sergeant Major Dunne, they were fired at in the Quamina Attah Croom, about a mile south of Mansue.

18*th November*, 1873.—The following days were at Mansue chiefly taken up with reconnaissances to find the Ashantees, the work in rear of Mansue progressing, the work at Mansue being still in progress, and nothing being done ahead of that place.

21*st November*, 1873.—The C.R.E. taking with him Lieutenant Bell, R.E., 240 labourers, the Denkera tribe, 420 strong, Lieutenant Hearle, R.M.L.I., a company of Cape Coast Castle Volunteers, and a party of police, moved from Mansue to Acrofoomue. There was a little skirmish on the march, but the whole party got into Acrofoomue, cleared the ground and encamped. Acting Sergeant Major Dunne and 80 men were left at Mansue to finish up the work there.

The road was then cut back from Acrofoomue to Dadiasue, and forward to Sutah; this road was intended to be completed at once, the party under Lieut. Mann at Dunquah being directed to finish to Dadiasue only. The bridges were made and the swamps corduroyed. Several skirmishes took place with the Ashantees, whose main body was within about two miles of the road.

At this period, it having been reported that the railway from England was to arrive in a short time, the C.R.E. wrote to the Chief of the Staff requesting instructions on the subject. (*Vide* Appendix XIII.)

On the 24th, Lieutenant Colonel Wood, V.C., arrived at the head of the road with his regiment, and took command of the advanced parties.

On the 26th, the road having been completed to within two miles of Sutah, and cut into that place, the whole camp moved to Sutah; the ground was partially cleared and levelled, the native troops and labourers hutted themselves.

27*th November*, 1873.—The road was finished back from Sutah, with the exception of the swamp, about 150 yards long, and a portion was cut north of Sutah.

The Major General having directed that huts for 50 Europeans should be got

ready as soon as possible, the materials for two huts, to form a portion of the intended encampment, were collected. The swamp south of Sutah was found to be very difficult to manage; it was produced by a network of fallen trees, which had dammed a small stream, causing it to overflow. These trees had to be cut through, to allow the water to run off. Drains had to be cut, and the old path abandoned, an entirely new road being cut through the forest so as to turn the swamp. The difficulty of this work with untrained labourers was very great, every tree that was cut down was so intertwined with creepers, that when cut it would not fall, but remained in its place supported by others until sometimes four or five trees had to be brought down. The mass of branches and foliage, knotted together with creepers, was thus very great, and as the trees fell, the huge ants' nests were broken, and the ants running all over the place, actually drove the men from their work. So wet and filled with sap were all the trees and undergrowth, that they would not burn. The labour of getting the road through or over a swamp was always very great, the hard wood of the country being crooked and unsuited for corduroy work.

Lieutenant Bell, R.E., was seized with fever, and unfit for duty.

The C.R.E. was similarly laid up, and Lieutenant Hearle, R.M.L.I., with Sergeant Dickson, R.E., at this period did the work alone for some days.

North of Sutah the swamps were even worse, some being 700 yards in length, and so wide that they could not be turned. Indeed, the whole of the country between Faisowah and Sutah was the swamp or morass where the Okee took its rise, and to relieve this water-logged country would have required a system of artificial drainage far beyond the powers of the Engineers. The object being to obtain merely a dry causeway for the troops to march on, the streams were relieved as much as possible. Deep trenches were dug on each side of the road, as is done in Ireland when a road is taken through a bog; fascines of brushwood and trees 6 in. in diameter were laid on the road, and the whole covered with the clay dug out of the trenches. While this work was going on, two huts were built similar to those already described, the road having been pushed as far as Attoh-Insue, four miles north of Sutah. During this time there was much traffic on the road, and incessant rain; the raw clay road suffered much, it never got a moment to dry, and was trodden and churned up into mud. The continued rain and heat caused many of the labourers to suffer from fever, and the desertions at this time were very numerous. The Engineer labourers were at all times better off than the Control labourers, as they were issued a ration of rice daily. But rice is not the food of the African negro. He likes plantains, and is ignorant of how rice should be cooked. The quantities of rice and plantains the natives ate continually caused swelling of their stomach and indigestion, and working in the swamps caused many of them to suffer from guinea worms.

On the 1st of December the C.R.E., having been informed that the Major-General Commanding was moving up the road to inspect its progress, returned to Mansue to meet him.

The C.R.E. found that the camp at Mansue was so far completed that the party there might be moved to the front. He therefore directed Acting Ser-

geant Major Dunne, with 200 men, to move from Mansue to Sutah, to complete the camp, two huts of which had already been built.

Mansue was at this period in excellent order; Lieut. Colonel Webber, commanding 2nd West India Regiment, had employed the men of his regiment in clearing the parades, burning bush, and clearing a large space into the forest; the sanitary state was excellent.

2*nd December*, 1873.—The C.R.E. proceeded down the road, and found Lieut. Mann at work a little south of Wonkorsue, to which point the Major General had got. The General had come in his hand carriage from Cape Coast Castle, and it was a matter of great gratification to the officers of Royal Engineers to find that he was pleased with the way the work had been executed.

There was at this time much sickness amongst the Engineer non-commissioned officers, eight out of the twelve being laid up with fever. On hearing this, the Commodore, Sir G. Hewett, who accompanied the General, placed at the disposal of the C.R.E. twelve carpenters of the Royal Navy, and despatched instructions to the squadron to have them landed, and also to have a quantity of canvas made up by the naval sailmakers for walls for huts. It was at first intended to use this canvas at Inquabim and Acrowful, but subsequently it was all sent to the Prah.

The assistance thus afforded to the Royal Engineers by the Commodore was very great, the naval carpenters one and all worked well and heartily, they were always cheery and did most excellent service, and in all subsequent mention of the Royal Engineers it should be remembered that these men formed a portion of the force. It is no exaggeration to say that, but for the Commodore's aid, the camp at Prahsue could not have been built so quickly as it was. And this was not the only place or time where the Navy aided the Engineers cheerfully in carrying out the common work.

3*rd December*, 1873.—The C.R.E. received instructions from the General to increase the store accommodation at Mansue; this was marked out and begun, the foreman, Mr. Nylander, being left to complete it.

4*th December*, 1873.—The C.R.E. proceeded to Sutah, marked out the camp there, and, leaving the sergeant-major and 200 men to complete it, he proceeded on the 5th to Faisowah, where Lieut. Colonel Wood was now posted. The road party being at Attoh-Insue, three miles in rear of it.

Fifty sailors and marines were now at Sutah, and these men worked for a couple of hours each morning and night in cutting bamboos and stacking them for the building party.

The road was now completed to within a short distance of Faisowah, but the swamps were still very bad, the first layer of fascines and corduroy was sinking under the traffic, and the continued rains were keeping the rivers full.

6*th December*, 1873.—The Major General arrived at Faisowah, the road was completed to that place, and cut ahead for some short distance.

7*th December*, 1873.—The road was continued ahead, but the number of men began to fail, owing to desertions, which now became rapid. Lieut. Colonel Wood, who commanded the native regiment, helped the Engineers by detailing

a company daily for work with an officer, this was a great assistance. At this time the Engineer labourers numbered as follows :—

	Men.
At work on the head of the road	250
Bringing up rice to feed the labourers	100
At Sutah, building encampment under Sergeant Major Dunne	170
At Mansue	50
At Yancomassie, under Sergeant Annet	150
With Lieut. Mann on the road between Mansue and Wonkasue	220
At Acrowful, under Sergeant Loxton	180
At Inquabim, under Sergeant Page	180
At Cape Coast Castle	70
Total	1370

The men, from some unexplained cause, now began to desert rapidly, and to desert even when large sums of money were due to them. One reason appeared to be that when money was paid they had no means of spending it, the advance having been so rapid that the women who usually followed in rear with things for sale had not been able to keep up.

The greatest trouble and difficulty was caused at this time, and indeed throughout the whole expedition, by the payments.

In England, during peace time, it is an axiom that an Engineer officer does not pay money : there have been exceptions, but they have been rare. During the Gold Coast Expedition, money was issued to the Engineer officers in bulk, and had to be paid in small sums to all the labourers.

This necessitated the Engineer officers moving continually from their work to pay detached parties, and also their carrying large sums of money about with them. The Control Department issued money to the various officers of Engineers at the various stations, the whole being charged to the C.R.E. Each officer sent his pay lists and an account of his disbursements monthly to the office at Cape Coast Castle, and the vouchers were then entered by Captain Buckle and passed on to the Control Paymaster. It was impossible to check the accounts, as the check could only be applied when the outstation paymasters sent their accounts to the Head-quarter Pay Office. It is due to Captain Buckle to state that he carried out this onerous duty most carefully and well.

On the 8th December, the road having been cut nearly to Yancomassie-Assin, the camp moved to that place, and work was begun on the road back towards Faisowah, and also on two huts for the 50 sailors and marines now at Sutah, whom the Major General wished to move up to Yancomassie-Assin, to support and protect the head of the road.

9th December, 1873.—The labourers still deserted in large numbers; the Denkera King and Chiefs were informed that their allowances would be stopped if the men deserted. At this period the men would not work ; they formed small knots, sat down and talked vigorously, but could not be induced to work ; it was not advisable to try force in the then existing state of affairs, and the Chiefs

were asked to state what the men complained of. This they agreed to do the following day.

The Major General Commanding approved of Lieut. Hare, 22nd Regiment, being attached to the Royal Engineers as Assistant Engineer.

10*th December*, 1873.—Proceeded to the Prah with Captain Buller, Deputy Assistant Quartermaster General, to select a place for encampment.

It had been originally intended (acting on local information) to make the final station at Dansamsue, about thirteen miles from Yancomassie-Assin, and the object of the reconnaissance undertaken by Captain Buller and the C.R.E. was to determine whether this place was suitable or not, and further to see the Prah and the road in advance. The result of this reconnaissance was that Dansamsue was found most unsuitable and that the necessity of having the final camp on the Prah was strongly impressed on both officers, notwithstanding the evil reputation of the place since the camp in 1863. This necessitated the formation of an intermediate camp at Barraco, which of course was so much additional labour.

11*th December*, 1873.—The Denkera Chiefs stated that the men were discontented because they were worked too hard and not well enough fed. They wanted their pay raised from 1s. to 1s. 3d. a day. A pound of meat daily in addition to the $1\frac{1}{2}$ lb. of rice, and that work should stop each day at three o'clock; of course these terms were rejected, and the Chiefs informed that they must work on the old footing. The two huts having been constructed, the sailors and marines moved up from Sutah, and a hut for stores was begun. The progress of the work was now slow, as nearly 200 men had deserted from the head of the road during the last ten days.

The C.R.F. hearing of the arrival of the 28th Company Royal Engineers, proceeded to Mansue *en route* for Cape Coast Castle. He left Lieut. Bell in charge in front, with instructions to push the road through to the Prah, and build two huts at Barraco for the 50 seamen and marines whom the General wished to keep well to the front: the road was finished to Acomfudy this day. The sailors and marines again worked, cutting bamboos for the camp at Yancomassie-Assin, both in the cool of the morning and in the evening.

The C.R.E. found the road between Faisowah and Sutah very bad, and he directed the Acting Sergeant Major, then at Sutah, to place a second layer of corduroy on it, and ordered 130 fresh men sent from the rear to Mansue, to halt at Sutah, thus raising that party to 230 men.

A body of 150 Winebah men were met carrying loads to the front, who, on their arrival there, were to strengthen Lieut. Bell's party.

12*th December*, 1873.—The camp at Mansue was now entirely ready, and in a good state; Pl. XX. shows its plan and general construction. Deep surface drains had been dug to carry off water in the heavy rains, and the hospitals were very comfortable and on the whole healthy.

Lieut. Mann had now brought his party within two miles of Mansue; the road was much improved, cut to its proper width, and in good order, except in a few places. The dry weather so long expected was said to begin about the 25th and last until the end of January; and it was hoped that even the wet muddy spots on the road would be dried up when the white troops advanced.

13*th December*, 1873.—Lieut. Mann was ordered to finish the road to Dadiasue, the point where the complete road began, and then march to the front and report to Lieut. Bell at the Prah.

14*th December*, 1873.—The C.R.E. proceeded to Dunquah and found large quantities of Engineer stores waiting to go to the front, especially rope and pontoons; these were despatched the same evening.

At Yancomassie, Sergeant Annet was ill with fever. He was removed to Dunquah for medical attendance, and the camp, now far advanced, left in charge of Naval Carpenter Weeks. A large Crease's filter had been got up to Yancomassie, and over all the bridges but one with safety; this was fortunately close to Yancomassie, and was being repaired by the party there.

The camp at Acrowful was also in a forward state, and that at Inquabim completed. The party at Inquabim, 160 strong, were ordered to move the following day to Yancomassie-Fantee, and on the 16th to Yancomassie-Assin, so as to complete that camp, two huts and a store only having been built by the advanced party. On the road between Dunquah and Mansue the C.R.E. met Lieutenant Skinner, R.E., and five men of the 28th company R.E. This party was ordered to proceed to the front at once, and report to Lieutenant Bell. Lieutenant Skinner told the C.R.E. that Lieutenant Jekyl and 15 men of the Telegraph Detachment had been landed, and the remainder sent to sea.

15*th December*, 1873.—With the Major General's sanction, orders were sent to the Himalaya to bring Major Jones, R.E., ashore, leaving the head-quarters of the company under Lieutenant Cotter, R.E., at sea.

16*th December*, 1873.—The C.R.E. was laid up with fever.

18*th December*, 1873.—Lieutenant Bell reported his arrival at the Prah, and the completion of the road to that place. A sketch of the camp furnished to Captain Buckle, who was directed to proceed at once to the Prah and take charge of the work there, Lieutenant Jekyl taking the telegraph and office duties at Cape Coast Castle.

It now became requisite to make a final effort, not only to complete the whole of the work south of the Prah, but also to prepare for further advance to the north of that river. The engineer labourers had hitherto carried not only nearly the whole of the engineer stores, but also the food and rations for Europeans and the officers' baggage. But it now became absolutely requisite to relieve the strain on other portions of the army, and reduce the engineer transport to a minimum, at the same time, that a sufficiency of tools should be carried to the front; the C.R.E., in order to meet the Major General's wishes, determined, on the completion of the large camp at the Prah, to hand over as many men as possible as carriers to the Control Department, and to form a pioneer battalion. The European force attached to the engineers would, on the arrival of the company, be 82 men of the Royal Engineers, and 12 of the Royal Navy, or 94; of this number, 12 might be expected to be unfit for duty; of the remainder, 25 composed the Telegraph detachment, leaving 57 available; of these, 12 would be required at Cape Coast Castle and on the line of communication, to keep the camps, roads, and bridges in repair, leaving 45 available for work in the front.

Of the Engineer officers there were, in addition to the C.R.E., 1 major, 1 captain, 5 subalterns, and 2 assistant engineers. It was therefore determined to leave Major Jones and Lieutenant Jekyl with the telegraph detachment, 25 Europeans, and 12 other sappers, or 37 in all, to form the line of telegraph and keep the roads and bridges in repair, while the remainder, with 583 labourers, were formed into a pioneer battalion, 180 men at Cape Coast Castle and on the road being detailed for service under Major Jones.

Four huts which had arrived with two rank and file R.E., from England for hospital purposes,* were ordered to be put up on Connor's Hill, and instructions were left for Major Jones to take charge of the line of communication when he landed. Major Jones's head-quarters were fixed at first at Mansue, but subsequently, by the direction of the Major General, they were shifted to Prahsue. The C.R.E. was thus compelled to break up the 28th company; but there was no option in the matter. Europeans can hardly labour in countries like the Gold Coast; their value is as superintendents of labour; as such they were most valuable. However disagreeable it was to leave any officers of Engineers behind, yet the maintenance of the line of communication was of vital importance, and, next to the advance, the most important work to be done. Hence it fell to Major Jones; and the skill and ability he displayed in improving the road and adding to the hut accommodation at the various stations, fully justified his selection for this very important duty.

On the 22nd, the C.R.E. left Cape Coast Castle, accompanied by Lieutenant Jekyl, and had the pleasure of seeing telegraphic communication between Inquabim and Cape Coast opened. At Acrowful he found the camp completed, and directed Sergeant Loxton to march next morning to Mansue, and from thence to Barraco, and complete the camp there. At Yancomassie the camp was nearly completed, and Sergeant Annet was directed, the moment it was done, to move on to the Prah.

The road as far as Mansue was excellent, and the hot sun had dried the wet places, leaving nothing to be desired.

Crease's large filters were in position at Inquabim, Acrowful, and Yancomassie; two of Crease's small filters were fixed at Mansue, and the galvanized iron tanks sent out for the railway were on their way to the front for the other stations, the portable filters being collected so as to empty into the tank. By keeping the filters continually full, it was hoped that pure water would be at all times available for the half battalion expected at the camp.

The bridge over the Okee, near Mansue, was found to require repair, the ants having eaten the suspender lashing, and the road near Sutah was found to be very bad, the rain continuing apparently longer there than at the Coast. Lieut. Bell was therefore directed to come back from the Prah and go to work on this portion of the road and bridge.

At Yancomassie-Assin, Sergeant Page had pushed the work so well that he was able to promise its completion on the 1st of January.

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* Vide Pl. XXI.

The C.R.E. reached Prahsue on the 25th, and found the camp cleared, much of the brushwood burned, a great number of the huts marked out, and that Captain Buckle and Lieutenant Bell, aided by Lieutenant Hare, 22nd Regiment, and Lieutenant Hearle, R.M.L.I., had done a great quantity of work.

The C.R.E. reported to the Chief of the Staff on the 25th of December, as follows :—

The following is the state of the Royal Engineer work :—

1. Inquabim completed.
2. Acrowful completed.
3. Yancomassie-Fantee to be completed on the 25th.
4. Mansue completed.
5. Sutah to be completed on the 27th.
6. Yancomassie-Assin to be completed on the 1st of January.
7. Barraco.—Two huts built; encampment to be taken regularly in hand to-morrow, the 26th.
8. Prahsue.—Skeleton huts for two battalions put up; Control stores for 70,000 cubic feet thatched in, and will be handed to Control officer at noon to-morrow.
9. Road in capital order, except nine miles from near Sutah to Foisowah; 200 men go to work on this to-morrow. I regret to say this portion of the road is very bad, otherwise I think the Major General will be satisfied with it. I expect to have all requirements ready in time.

I have to request that you will bring to the notice of His Excellency the Major General, the great assistance I have received from Lieutenant Colonel Wood, V.C., who has aided me in every way; indeed, I cannot express too strongly how much I am indebted to Colonel Wood for this assistance.

10. I regret that upwards of 200 labourers have deserted from the front since I left for Cape Coast Castle; the loss will fall, of course, on the number I can hand over to the Control Department. I have notified Colonel Colley accordingly.

R. Home, Major,
Commanding Royal Engineer.

The great difficulty at Prahsue was the want of hutting materials. On the south bank the palm leaves were almost entirely deficient, and they had to be procured from the north bank of the river. To carry the workmen across and bring back materials, there were only two rafts of Blanshard's Infantry Pontoons, and a large canoe left by the Ashantees. 200 to 300 men of Colonel Wood's regiment, with two or three European officers, were ferried across daily to cut palm leaves and stakes for hutting. On the arrival of Major Russell's regiment similar parties were given daily. Thus, owing to the assistance of these two native regiments, an increase of some 400 to 500 men was daily given to the working parties. The huts were of the same stamp as those previously constructed, but one foot lower. A portion were constructed with bamboo or palm stake sides, but by far the larger number were made of canvas, as shewn on Pl. XXII. These huts were most excellent.

26*th December* 1873.—A rope was got across the river so as to haul the pontoon rafts backwards and forwards.* Lieutenant Mann, who had been unwell, now became seriously ill. A place for the bridge was definitely selected, and a party put on to cut the bank down in a ramp, a considerable work, as it was 30 feet above the water. The camp had been marked out generally from a sketch made on the 10th of December by the C.R.E., when the ground was first visited; a drawing of it is given (see Pl. XXIII.) In laying out a camp for a large body of men, there is a certain difficulty in meeting all the requirements. The chief requirements here were air and water. To afford as much access as possible to the river (where there was always a slight breeze) was desirable, and at the same time it was essential that the latrines should be far away, and yet not too far. It is believed that, looking to the various requirements of the case, the camp was a good one. Had it to be laid out a second time, the Engineer on whom this duty devolved would probably have altered it, by doing away with the large central square, and forming two distinct broad streets or parades, but the necessity of having the water filters near every one caused the square form to be adopted.

In any formation of camp, it is impossible to meet fully all requirements, and at best, a selection of evils only can be made.

The bridge now became the great question. The Blanshard's pontoons were the only means available for crossing, and were far too few to rely on for the vast number of carriers that had to pass to the front. The Fowke pontoons were useless, rats and ants had destroyed them, and even if they had not been destroyed, their size and flotation were far too small to render them of any use whatever. Twelve trussed girders had been prepared at Chatham. These were very slight and strong, and would give a bridge across the river 2 ft. 6 in. wide. But considering the very important link in the communication this bridge was, it was determined to make the bridge not less than 5 ft. wide. Thus the trussed girders would give one half the roadway required, and the remainder consequently would have to be made up of material to be procured on the spot. The trussed girders were the development of a girder which had been proposed in 1856 by Major General Bainbrigge, and which it had fallen to the lot of the C.R.E. to experiment with at Chatham. The arrangement was somewhat different from that proposed by General Bainbrigge, both being however, mere modifications of the common tension rod or chain truss, extensively used at the Breakwater at Portland, and in the scaffolding on the Verne works, Portland.

These girders had been made at Chatham; nothing could have answered their purpose better. (See Pl. XXIV.)

At Cape Coast Castle some light four-legged trestles had been prepared for this bridge, but a very moderate examination showed that they would not be nearly strong enough.

Captain Buckle had made a section (see Pl. XXV.) and sent it to the C.R.E., Cape Coast Castle. This section showed that the river was

* This rope served also to keep off any drift timber, that might float down the stream, from damaging the bridge.

not only deep, but that the bottom was fairly regular, and of hard sand. There were no means of driving piles, and such light trestles as the tackle on the spot would get out, would undoubtedly be carried away in a short time, as the current was running nearly four miles an hour, and freshets were to be expected. Under these circumstances crib work piers were determined on, and Pl. XXV. shows the rough design for the bridge at first made, but subsequently altered considerably. The place selected for the bridge was below a projecting point on the bank, which produced a small eddy; this eddy was selected as a convenient place for launching the cribs. (*Vide* Pl. XXVI.)

A stake was fixed in each bank so as to mark the centre line of the bridge, and a take-off was prepared by fixing a trestle in the water as deep as the men could work, or about 5 ft.; this take-off spanned about 9 ft., and was made of rough timber, and as strong as it conveniently could be. A crib was then constructed on ways; it was 8 ft. by 6 ft. at the bottom, and battered up to 4 ft. by 3 ft. at the level of the water. The construction of this crib is shown (see Pl. XXVII.); the portion above water was not put on, as it would have made it inconvenient for launching, but was kept on the bank, separate. Two anchors were laid out as shown on Pl. XXVI. Barrels were attached to the crib to give it some additional buoyancy, the timber being very heavy; four sand bags were filled and lashed one in each corner of the bottom, which was composed of a cross-barred frame. These sand bags and the barrels caused the crib to float vertically.

The bight of the cable between the anchors was adjusted so as to be nearly 30 ft. clear of the shore end; a buoy with a block was attached; a rope rove through the block as a haul out; a rope was carried to the other side of the river, and the crib was launched down the bank, a preventer rope being passed round a tree at the top of the bank to keep it from going too fast. It was found to float generally 2 ft. out of water.

The haul out was manned, the crib hauled up to the block on the bight of the cable, and then allowed to drop slowly down to its position; a rope 28 ft. long was attached to the shore end of the bridge, so as to allow a bearing of 1 ft. at each end; and so soon as the crib got into its proper position, the pontoon raft, loaded with sand bags, came close up, the slip-knot attached to the barrels was let go, the barrels floated up, and sand bags were thrown into the crib, mixed with rice boxes and bread bags (there were only 100 sand bags available).

The day after the first crib was launched, it was found to have sunk 17 in. into the mud, and to be only 4 in. out of level, this was easily made up by putting a couple of thick sticks on the low side. The crib was raised to its full height, and transoms of roughly adzed timber laid on. The girders were then got into position, and the first span of the bridge was thus completed.

The Major General having directed that the bridge should not be gone on with until his arrival, nothing further was done with it until his arrival on the 3rd of January, when it was begun at both ends, and finished on the 5th. The spans where native timber was used were reduced to 20 ft., as nothing was known of the bearing power of the timber, which was chiefly a kind of mahogany and cotton wood.

The third crib from the south bank, and consequently the middle of the river, was the only one that gave any trouble. It grounded on a large stone about 3 ft. out of the proper line, and could not be got to float over this stone, although a considerable lifting power of barrels was applied to it. It was therefore loaded; next day it was found to have slipped 15 in. out of its place. To secure this crib temporarily it was strutted with piles, and the roadway formed over it, the top being levelled up with thick timber on the low side. The shore side on the north bank was carried on three trestles made of rough timber lashed and braced together. The bridge should have been finished on the 5th at 10 a.m.; it was not however completed until 3 p.m. the same day, when the rear guard and baggage of Russell's Regiment moving to the front passed over it.

The crib that was out of place showing symptoms of moving, it was relieved by driving strong piles on each side and carrying the roadway on a cross transom lashed to these piles. The crib was thus useless and might have been removed, but it did no harm, and was left in its place. The cribs were all finally lashed with a 3-inch hawser, the roadway secured with telegraph wire and 10-inch spikes, each crib further strutted on the down stream side, and an apron of sand bags and rice boxes thrown in to prevent any movement; a hand-rail was subsequently added. Although exposed to a very severe flood, which rose nearly to the roadway, the bridge was six weeks after apparently in the same state as when completed, and did not appear to have suffered at all. The entire number of working hours taken in making the bridge was 61. The Royal Navy helped greatly in the construction, there being then only five sappers fit for duty at the Prah; the carpenter's work was chiefly done by Carpenters Salter, Llewellyn, and Parminter, and the superintendence by the late Serjeant Barthorpe, R.E. The lashing of the cribs was performed by seamen of the Naval Brigade, who also aided in hauling out the cribs.

A magazine to hold a million rounds was constructed near the Control Stores.

The Major-General Commanding arrived on the 3rd January in his carriage, in which, with the exception of the bad road near Sutah, he had travelled from Cape Coast Castle. It was a matter of no little gratification to the C.R.E., and his officers, to find that His Excellency approved of what had been done. A report was at this time made to the Inspector-General of Fortifications, *vide* Appendix XVII.

At the beginning of the year Lieutenant Skinner became so ill that the medical men declared he must be sent back to Cape Coast. He was accordingly carried to the rear in a hammock, to the regret of every one, as he had worked most zealously during his short stay in the country. At this time it became apparent that Lieutenant Mann, who had done much good hard work, and had borne sickness and exposure in the hope of eventually getting to the front, would be unable to do so. Nothing but his great pluck had hitherto saved him, and at this time he was so seriously ill that he could not be moved to the rear.

The Engineer parties now began to come in rapidly; on the 29th, Sergeant

Annett came in from Yancomassie Fantee; on the 2nd, Sergeant Page from Yancomassie-Assin; on the 4th, Lieutenant Bell, with the Acting Sergeant Major, from Sutah, having put the 3rd tier of corduroy on the troublesome swamps.

As the parties came in, the work progressed rapidly; by the 7th of January the whole of the huts were finished, and the *tête de pont* (*vide* Pl. XXVIII.) on the north side begun, the clearing round and in its neighbourhood being done by the sailors in the morning and evening; on the 8th, Sergeant Loxton marched in from Barraco. By this date the whole of the hut encampments were finished, and about 500 labourers were handed over to the Control Department as carriers.

8th January, 1874.—A strong party was put on to cut the road to the front towards Essiaman, which was then occupied by Major Russell's Regiment. The detachment of the 28th Company, Royal Engineers, under Lieut. Cotter, R.E., accompanied by Dr. Murphy, marched in. The Company was quartered in the hut built for them in the Engineer Park.

The men were now told off to their various squads or parties, and the work proceeded much more rapidly and regularly; the enormous advantage of the white supervision soon showed itself, not only in the saving of the officers, but in the rapidity with which the work was executed. The Pioneer battalion was formed as shewn in Appendix XIV.

On the 9th of January, the left wing of the Pioneer Battalion, under Lieut. Cotter, was pushed along the road to Atto Biasse, with instructions to cut the road forward until the road being made by Major Russell from Essiaman was met.

On the 10th, the C.R.E., with Lieutenant Bell, R.E., and Lieutenant Hare, 22nd Regiment, moved to Essiaman with the centre column; the right column and park being left at Prashue, under Captain Buckle, R.E. A General Order of the 9th January, relative to the Telegraph and Engineer matters, is given in Appendix XV.

The road to Essiaman was completed that evening, the road in advance continued.

The Major-General Commanding having directed a post to be formed at Essiaman with a store house, Lieutenant Cotter and the left wing were directed to perform this work. This post was ordered to be a stockade, and Lieutenant Cotter was directed to make one accordingly. The great want of transport at this period induced the C.R.E. to increase the loads of the labourers; in place of 6 pickaxes, or 43 lbs., 9 pickaxes or 63 lbs., was placed on the heads of the carriers. By this means not only was the whole of the food eaten by the Royal Engineers beyond the Prah carried up from Prahsue, but by loading every spare man with provisions, some assistance was given to the Control Department. The carrier and the workman being one man, and when working the workman requiring only one tool, by arrangement some little aid could always be given to the general transport while the Engineers were entirely independent.

The parties marched with 10 days' rations from Prahsue, and carried each 40 loads for the general store at Essiaman, and Lieutenant Cotter was directed to put 30 loads daily into that store, and eat nothing that came out of it. The Engineer force was at this period at its best, and the mode of working was as follows.

A guard of a sergeant and 10 men of the native police was attached to the Royal Engineers, a sentry was mounted over the tools and provisions, which were usually close to the officers' tent. A little before daybreak fires were lighted and each European had a dose of quinine, a mug of cocoa, and a piece of biscuit, the men's cocoa being prepared by their cooks, there being one cook to every six men. The men messed in messes of six, or two *tentes d'abris*. The natives were called at daybreak and were usually ready about half an hour after; each Sapper collected his party, and saw they were supplied with tools. The tools were issued from the field park; a native who could read and write, and a European, generally a man who was not fit to go out, kept a check of the tools; a few men were left in camp under the Europeans to grind axes and cutlasses and mend tools.

The labourers were extended along the road by an officer who pointed out what was to be done; the cutlass men cut down the bush, the hand-axe men grubbed up the stubs, which were so sharp as to cut a boot, the axe men cut down any tree or cut through any that were across the road. Each sapper carried his rifle and 70 rounds of ammunition and kept his own party at work, the officer moving about amongst them and directing from time to time what was to be done. At 10 o'clock word was passed along the line to come in, the whole party returned, rations were issued, and the breakfasts—tea, rice and preserved meat—ready by 11 o'clock; at 1 p.m. the men turned out again, and worked until it was dark, when they returned to camp, dinner was ready in about half an hour, large fires were made in front of the *tentes d'abris*, one to every three tents, and a huge fire in the middle of the camp, the men to make these fires and gather the wood having been specially told off. After dinner the rum was served out, and the men smoked, sang glees—at which the sailors attached were capital hands—and turned in about half-past eight. The work, owing to the superintendence of the white Sappers, made at this period rapid progress. The black labourers had become to a certain extent drilled to the use of tools, they were in an enemy's country and could not desert, and, indeed, were only anxious to be as close to the white men as possible.

The small amount of sickness at this time amongst the Engineers (only one man was sent back sick from north of the Prah) until the return to Cape Coast Castle was due to the great precautions in making raised beds for the men to sleep on, in lighting fires, and always carrying filters for the use of the men;* these precautions, and the very liberal rations, kept the men in health. Whenever an opportunity offered, the men were made to wash in a stream, and each man was seen daily by a medical officer.

* Portable filters in addition to the pocket-filters were carried.

11*th January*, 1874.—The road having been completed to Ansah, about 4 miles beyond Essiaman, and the streams bridged, Lieutenant Cotter was directed with the left wing to complete the work at Essiaman, while the centre, now accompanied by Dr. Murphy, R.E., moved on the 12th to the Foomasue River, where the advanced posts were. The road was cut back to Ansah that day, and a bridge got across the Foomasue River, a large rock in the centre being used as a pier. and two spans of 20 feet each being required.

In the evening the right wing, with Captain Buckle, R.E., Lieutenant Hearle, R.M.L.I., and the park, arrived from Prahsue. This party made the 19 miles march in one day.

13*th January*, 1874.—The approaches to the bridge were completed, and the road cut forward as far as the Parakoomee River.

14*th January*, 1874.—A party sent to Accrofoomue to begin the entrenched post, clearing, store, and hospital there. While the road was continued on the 15th, 100 men were sent to Prahsue for rations, and a second bridge got across the Parakoomee River, north of Accrofoomue. The post at this place was similar to that shown on Pl. XXIX. The bridges usually made are shown on Pl. XIX.

16*th January*, 1874.—The road was pushed to Ahquansraimue, the advanced post; the post at Accrofoomue, nearly finished, ground cleared, and the hospital and store in a very forward state.

100 men sent back for rations.

A copy of a letter to the Chief of the Staff is appended, showing the state of affairs at this time. (*Vide* Appendix XIX.)

18*th January*, 1874.—The park, with 2 non-commissioned officers and 50 men, was left at Accrofoomue, and the remainder of the force moved to Moinsey. On the march, news having been received that the Ashantees were holding the hill, the Europeans were called to the front, and pushed on, but their services were not required. A sketch of the hill is given (Pl. XXX.), showing the little fort at its foot, and the zig-zag road over it it. The men were put on to cut the road back to Ahquansraimue, and bridge the many small streams on it. This work was undertaken by Lieutenants Bell and Hare, 22nd Regiment, Captain Buckle, and Lieutenant Hearle, R.M.L.I, looking after the fort and clearings. The following day, Lieutenant Cotter with his party arrived from Essiaman; and the road over the hill was begun, having been laid out by Lieutenant Bell. The native path was followed, Lord Gifford, Captain Buckle, Lieutenant Hart, and the C.R E. having all failed in finding a better direction.

20*th January*, 1874.—The rations arrived from Prahsue. The road to the rear was completed, and that over the hill in a forward state. The whole Engineer force, officers and men, was now concentrated at this point, and after deducting desertions, there were 500 labourers and 45 Europeans. Tools had been left at each post on the road (Essiaman, Accrofoomue), and a small party was sent to form a post at the junction of two roads, about a mile and a half south of the Moinsey Hill, where an important road joined the main road. The provisions now in front gave 16 days' rations for both Europeans and natives, and finding

that the rapidity of the advance and the severity of the work had told on many of the natives, they were all medically examined by Dr. Murphy, and 37 were paid up, furnished with passes, and discharged. The road over the hill was a heavy work, as it was nearly all pickaxe and shovel work, and at the returns, and where it crossed the native path, had to be supported as shown on the section (Pl. XXX.) The work was well performed, and stood much traffic; the soil was of a rubbly nature, chiefly of decomposed granite. This work was superintended by Lieut. Bell, R.E. The fort having been finished, and the road to the top of the hill and partly on the other side having been completed, the Engineers moved to Quisah, leaving one officer (Lieut. Cotter) and some men at Moinsey to do any work the General might wish on his arrival there.

Quisah was entrenched that evening, a clearing made round it, and the road completed up to that point. A report was received here that Lieuts. Jekyll, Mann, and Skinner had been invalided.

22*nd January*, 1874.—Three huts begun at Quisah to give additional accommodation for men and stores, road cut half a mile in advance to advanced posts, latrines dug for troops. Captain Buckle, R.E., Lieut. Hare, 22nd Regiment, both ill at this place, and the detachment left at Moinsey marched in, reporting Lieut. Cotter ill with fever at that place.

23*rd January*, 1874.—Moved to Foomanah, completed road up to that place, began a small fort with store and hospital in advance of that place, cleared as much of the bush round the place as possible, and formed deep latrines for Europeans.

24*th January*, 1874.—Cut the road up to Dompoassie. Captain Buckle, Lieut. Cotter, and Lieut. Hare rejoined, being better.

25*th January*, 1874.—Captain Buckle, with Lieut. Cotter, left to complete the work at Foomanah, with the park and 200 men. The remainder moved to Dompoassie; road cut and formed close to Kiang Boassue.

26*th January*, 1874.—The Europeans marched *via* Addubiassi and supported the attack on that village, to Kiang Boassue; the labourers proceeded there direct; a bridge got over the Bahrein River that night, the ground cleared, the village of Medouma prepared for Europeans by burning the dirt and digging deep latrines. C.R.E. ordered to examine the villages in front, proceeded to Essang Quantah, and having obtained an escort from the scouts there to Detchiasue which the Ashantees had just left, reported neither of these villages as suitable for Europeans. Captain Buckle and Lieut. Cotter marched in, and were sent to encamp at Essang Quantah, and directed to work on the road to each side of that place. This section of the road was the best found during the course of the expedition; for four miles, beyond cutting trees in two, removing them where they laid across the path, and bridging the streams, nothing required to be done.

27*th January*, 1874.—C.R.E. ordered to examine the villages in front, and report on a camping ground for troops. Proceeded through Ahkankuassie with an escort to Denkeran River; on his return found the Scouts and Houssas in occupation of Ahkankuassie. Reported that place as the best for Europeans. Captain Buckle moved there. Lieut. Bell to Detchiasue. Lieut. Bell made the

road, a very bad section, from Detchiasue to Ahkankuassie. Captain Buckle cleared the ground round the village, commenced a little fort, store, and hospital, and 100 men cut the road in advance; dammed a stream to improve the water supply, and formed about 300 yards of corduroy.

28*th January*, 1874.—Road completed up to advanced post at Adadwassie; fort and store in progress; very heavy rain all day.

29*th January*, 1874 —Captain Buckle, Lieut. Cotter, and the park remained at Ahkankuassie. The remainder of the force moved to Insarfue. The road from Adadwassie to Insarfue very bad.

It became apparent that Insarfue would be a place of consequence, and, from circumstances, that the first fight would take place very soon. The men were told that the road must be opened to Quarman, and the Denkeran and Yansie bridged before work stopped that night; this was a distance of about three miles, and there were many swamps and bad pieces of road. Double pay was promised to every one if this work was accomplished. The road back to Adadwassie was finished, and the Denkeran bridged by four o'clock, and by dark not only was the Yansie bridged, but the road was made into Quarman, a fresh road for nearly a quarter of a mile cut through the bush to the north, and a bridge over the Dunsaboo begun. It now became apparent that a very small advance would produce a collision between the Ashantees and the main column, the head of which advanced to Insarfue, the advanced guard and Engineers having moved to Quarman. Orders sent to Captain Buckle to send the park to the front as soon as possible.

30*th January*, 1874.—Orders sent to Captain Buckle to come to the front, and to Lieut. Cotter to move to the front when his work was done.

The bridge over the Dunsaboo completed, and the road cut by Lieut. Bell to within 130 yards of the village of Egginassie, the Ashantee outpost. Large clearings made round the village of Quarman partly by the Engineers, partly by the men of the Native Regiments, Wood's and Russell's. The advantage of one park of tools was now apparent, the grindstones were kept at work night and day, and the tools supplied to the Engineer labourers and the native troops were thus always sharp and efficient. Indeed, the economy of tools, and—what was of much more importance—of transport, was very great

The same description of tool was rarely or ever wanted at the same time, and consequently a smaller number of tools were required, and therefore less transport; further, the tools were always sharp and serviceable.

The Major General Commanding sent for the C.R.E. and informed him that he proposed attacking the enemy said to be in position near Amoaful the following morning. And pointed out the method in which he wished to attack, in three columns, covered by the 42nd Regiment in front as skirmishers. He further directed the C.R.E. to prepare for cutting three roads the following morning. These roads to be at 300 yards to the right and left of the native path, which ran generally due north and south. With this view it was determined to send with each column 40 natives and one sergeant and 10 rank and file of the Royal Engineers. Three naval carpenters accompanied each column, making the force one sergeant, 13 Europeans, and 43 Natives. Three Europeans had to be left behind sick in the morning.

Captain Buckle was ordered to take command of the left column, Lieut. Bell of the right column, while Lieuts. Hearle and Hare took charge of the centre column which was also accompanied by the C.R.E. The flank columns were ordered to cut 450 yards to the north-east and north-west by compass, and then to cut due north and south.

A place was cleared on the other side of the Dunsaboo river where the labourers might stand and file into their places without blocking the road.

It was at this time a matter of much doubt whether the Fantee labourers armed with cutlasses would venture into the bush and clear a road for the infantry. The Europeans were told that in case of necessity they should be called on, but until such was the case, their duty was merely to keep the natives up to their work, there being one European for four natives; they were directed to fire as little as possible, and to encourage the natives to work. The close nature of the bush, the difficulty of overseeing the men, and the impossibility of taking a large body of labourers without blocking the roads, and consequently impeding the advance, caused the number of labourers to be fixed at only 43 for each party. That evening the whole of the tools to be used the following day were sharpened. The men for the work were carefully selected from amongst those that had served longest with the Royal Engineers. A ration of rice for each black man was issued, cooked in the evening and tied up in his cloth. Each European was furnished with a sausage and some cheese.

It having been decided that Quarman was to be held, and the baggage of the advance guard left there, it was strengthened that evening. Dr. Murphy being ill, Dr. Conyers was detailed for duty with the Royal Engineers.

31*st January*, 1874.—Camp was struck at 3 a.m. The Europeans and natives were given a good breakfast. The water bottles of the former filled with cold tea and rum. The camp equipage parked at 6 a.m. Lieutenant Cotter, R.E., marched in from Ahkankuassie with the park. He was directed to remain at Quarman with the baggage and park, and put that place into a state of defence; two of the Europeans who were sick were transferred to his party, and two sound men taken in their place. The Sergeants were told off as follows:—Sergeant Loxton with Lieutenant Cotter at Quarman; Sergeant Page with Lieutenant Bell and the right column; Acting Sergeant-Major Dunne with the centre; Sergeant Taylor with the left column.

The head of the European Brigade began to arrive at 7 a.m. The Engineers of the centre filed in behind the second company of the 42nd Regiment.

Those of the right and left columns filed in their proper places and the whole moved off.

A few shots were fired in the village of Egginassie and some fallen trees across the road were removed and cut through. The companies in front meeting with opposition, a road was cut in on the left flank which turned the Ashantee position. The path was widened and the centre party divided, one portion remaining under Lieutenant Hare, to clear the bush on the sides of the path, the other pushing on with the advance, which was rapid, as the bush here had been much cleared by the Ashantees themselves in forming their

camp. In the middle of the camp there was a small marshy stream, across which a slight corduroy was put to facilitate the advance of the guns; as the advance was pushed up the hill to Amoaful the bush was cleared, and when the village was carried, about half-past 12 o'clock, it was at once loopholed and strengthened to resist any attack. The Ashantees clung to the village so strongly that one Engineer labourer was killed and two wounded while loopholing the village. Another was blown up with a keg of Ashantee powder.

On the right, Lieutenant Bell's party had cut out to the flank about 100 yards from Egginassie when they were met by a heavy fire, 2 sappers wounded and 8 natives killed or wounded. This column made a very large clearing in this place, to the east of Egginassie, and extending for some distance along the main road, uniting with the party left under Lieutenant Hare, and cutting across the main road. The fire here was very heavy.

On the left, Captain Buckle had cut out about 250 or 300 yards, when he was met by a heavy fire, he himself was killed, and several of his men killed or wounded. The want of an officer here caused the direction of this column to waver, and after advancing some distance and clearing the road, they cut into the main road a little to the south of the swamp, and joined the party under Lieutenant Bell*. The death of Captain Buckle, R.E., was a great blow; ever zealous, hardworking, and energetic, he had displayed great talents, and evinced much knowledge of his profession. He fell performing his duty in the most gallant manner. His loss cast a deep gloom over the little Engineer party, now greatly reduced by sickness.†

The total force of Engineers taken under fire was:—

Officers, Royal Engineers	3
Officers Assisting Engineers	2
Royal Engineers (Rank and File)	29
Naval Carpenters	8
Native Labourers	129

The loss was, 1 officer killed, 2 wounded, 4 rank and file Royal Engineers wounded, and 7 natives killed, and 25 wounded. The Major General having determined to make a post at Amoaful, it became requisite to call up the park and baggage from Quarman, $2\frac{1}{2}$ miles in rear; orders were sent to this effect, but the park and baggage did not arrive until the morning. Meantime at Quarman, the Ashantees passing round the flank attacked this post; Lieutenant

* A report from Sir John McLeod, 42nd Highlanders, to this effect:—"Send me Engineer labourers, mine have bolted," having appeared in one of the histories of the war, Sir John McLeod called on me to explain that he wrote this under the impression that a report he had received was correct; on going to the front, however, he found all the Engineer labourers waiting for orders, exactly where Captain Buckle was killed; on speaking to them they at once resumed work. And he said, "in justice to these men, I wish to say I never saw men behave more gallantly in my life."—R.H.

† A sketch showing this action, with the positions of the troops, is appended. (Appendix XXI. and Pl. XXXIII.) This account and the sketch was compiled on board the "Sarmatian" by Major Robinson, Sir A. Alison's brigade major. The clearings made are shown on it. The path cut to the left of the main road is shown in dotted lines. Capt. Buckle was killed a short distance in rear of the large clearing made by the left column. The heaviest fighting was about the stream and swamp, in front of the main Ashantee position.

Cotter's small party, 10 sappers, did good work here, being for a long time the only Europeans, and the post was for some time closely attacked until relieved by the Rifle Brigade.

1*st February*, 1874.—Lieutenant Cotter, R.E., and the park, arrived at the front. A strong party were put on to bury the dead, clear the village, make latrines, and form a post. In the middle of the day a detachment was sent under Lieutenant Bell to Bequa with the column which burned that village.

As the advance was to take place next day, and was likely to be a rapid one, the weakly men were selected by the doctor to be left at Amoaful. Lieut. Cotter, R.E., who had met with an accident to his eye, Lieutenant Hearle, R.M.L.I., who was unwell, 14 weakly Europeans, and 230 natives were detailed for this purpose. Lieutenant Cotter was ordered to complete the fort, destroy such houses as might be prejudicial to the defence, clear the ground, and further, to afford all the aid he could in carrying provisions, and sick or wounded men. It became desirable to select a few spare articles from the park, and to leave the remainder at Amoaful; amongst the articles to be so selected were the guncotton detonating fuzes and Bickford's fuze. On examination, it was found that the two boxes of damp guncotton were present, but the small dried discs and the fuzes could not be found. Captain Buckle had carried the dry discs in two empty boxes of snider ammunition, together with the fuzes, as a portion of his private baggage in a portmanteau. On his death, his baggage was sent back from Quarman to the Field Hospital at Insarfue; when his baggage was opened there to make an inventory, these things were found and sent to the front, but had never arrived. It turned out that the boxes had got mixed up with the reserve ammunition of the Rifle Brigade, and were actually issued to that regiment when under fire, as ammunition, on a subsequent occasion. Captain Buckle was most anxious that this guncotton should be at hand, and often spoke of the necessity of its being well up with the front and he considered he had provided for every contingency by making these things part of his own baggage. Strange to say, the very care he had taken was the cause of the guncotton not being available when wanted. Nothing of any sort or kind should ever be put in an ammunition box, however convenient it may be.

2*nd February*, 1874.—The Engineers paraded at 3 a.m. The force consisted of 120 natives, 25 Europeans, 2 officers Royal Engineers, and 1 assistant Engineer, Lieutenant Hare, 22nd Regiment. Thirty additional men carried 7 days' rations for the Europeans, and four days' rations for the natives; each native carried for himself a bundle of corn, large quantities of which were found in Amoaful. So far the provisions brought up to Moinsey had held out, and that they did so was due to the great care of Lieutenants Hare and Hearle, who performed the onerous and unpleasant duty of Quartermasters. To these officers the Engineers owe much, for they were always on the watch to procure extra food; no bullock was killed but they procured the Engineers' share, no fresh bread was baked but the Engineers' share was claimed and obtained. By these means, getting plantains, and securing sheep, which were sometimes to be found, &c., the preserved rations were husbanded.

The night of the 31st, when provisions were scarce, the Engineers had plenty, owing to some sheep having been caught, and in the advance on the 2nd a sheep was taken to the front in addition to the rations.

The Engineer force was now formed in two divisions, the advance moved with the advanced guard under Lieut. Bell, who was attached from that time to Colonel McLeod.

The reserve, under Lieut. Hare, which moved with the leading regiment of the main body, the few extra tools carried, and the baggage moving with the general baggage of the force.

On the 2nd, the road was generally fair, some trees were removed and cut, two small posts with clearings were made where side paths came in, and ramps were made down to the edge of streams. But little could be done, the advance was rapid, and it is impossible to do much to a narrow path over which troops are marching without delaying the advance; when the enemy attacked, clearings were made on each side of the road to allow a wider front to be shown.

Agemamue was reached about 12.30; after the men's dinner, a large area was cleared all round the village, partly for defence and partly to allow the white troops to encamp.

At 5 p.m. the Major General informed the C.R.E. that he wished a post formed to hold the baggage of the army, which he proposed leaving with an escort at this place.

The village of Agemamue was situated on a slope, and surrounded by heaps of filth, the accumulation of years. It was filled with the staff officers, sick men, and baggage of all kinds, and the streets were blocked up with the carriers of the army, who were preparing to pass the night there. The village itself, loop-holed, with the houses connected with one another, would have made the best post, but occupied as it was, it was impossible to do anything with it without causing much inconvenience. At the lower or north end of the village there were two paths, which branched off nearly at a right angle, and were hollow for 70 yards, with banks about 6 ft. high; these paths were about 9 ft. wide. Advantage was taken of them, and a triangular-shaped redoubt was formed, the paths forming the ditches on two sides. Work was begun at 7 p.m. By degrees the natives stole off in the dark and could not be found again. The work was, however, completed at 2.30 a.m. by the Europeans—sappers and sailors. As this post was of considerable importance, 35 labourers, with Sergeant Dickson, R.E., and a supply of tools were left behind to complete it, under the orders of Captain Cope, of the Rifle Brigade.

3rd February, 1874.—The advance was resumed at five o'clock, Lieut. Bell and his party still being under Colonel McLeod's orders. A running fight was kept up nearly the whole day, during which a very large clearing was made by Lieut. Bell, who, with an unarmed and uncovered working party, supported in rear, however, by troops, cut his way into a strong defensible position occupied by the enemy. One sapper was wounded; three natives killed and four wounded.

The river Ordah was reached that evening about three o'clock. So soon as

the men had dined, work was begun on the bridge. There was neither rope nor nails available for this purpose, and no material but what grew on the banks. Piers were formed, as shown on Pl. XXXI. The heaviest timber being selected for the piers, and the piles being driven by a rough maul, made out of iron wood. The men worked in the river until 9 p.m.; at that hour work was struck, and resumed at 12. The bridge was finished by daylight, or 5 a.m., on the following morning. During this night the men suffered much, as it rained very heavily the whole night, drenching the timber and putting out the fires. The whole of the *tentes d'abris* having been left at Agemamue, and the men, having to work at night, could not make shelter for themselves.

4th February, 1874.—At 6 a.m. the advance was resumed. Lieut. Bell, with the advanced guard, got into the village of Ordahsue. Here he was directed to clear a large space, a duty which he performed without being covered in any way, and in which he displayed so much gallantry and courage that he has been specially brought to His Royal Highness's notice as deserving the Victoria Cross. One sapper and three natives were wounded.

In European warfare, unarmed working parties work in rear of covering parties extended in front, and are supported by strong parties in rear. During the operations that took place from the 31st of January the bush was too thick to admit of troops covering the Engineers, who thus worked without a covering party at all, and exposed often to a double fire, not only from the Ashantees in front but from their friends behind, who, in the excitement of action sometimes did not pause to ascertain if the black man in front was an Engineer labourer or an Ashantee. During all this work the Fantee labourers behaved remarkably well, never showing the slightest hesitation, but going forward whenever they were directed. Working thus, without a covering party, the Engineers were much exposed. On the capture of Ordahsue the advance was resumed, the 42nd leading and the Engineers following the 2nd and 4th Companies. Coomassie was reached just before dark. The men were so exhausted at this time that they could hardly be induced to take any trouble to form their encampment, which was in one of the large houses in the main street. Police sentries were posted, large fires lit, the men's dinners cooked, and an extra ration issued to them. By 9 p.m., however, fires had broken out in various parts of the town, and the men had to be turned out to put them out—a work of great difficulty. No water was available, and the dry thatch of palm leaves caught so quickly, and spread so rapidly, that it was impossible to clear an opening; in addition to which, barrels of powder left by the Ashantees repeatedly exploded, scattering sparks in all directions. The fires were got under about 4 a.m.

5th February, 1874.—The Major General directed certain portions of the Palace fence and enclosure to be repaired. The men's arms were examined and cleaned, and the ammunition, of which each European had fired about 80 rounds, was replenished. It rained very hard all day. In the afternoon the Major General informed the C.R.E. that he wished to have the Palace blown up, and the town burned the following morning. The fate of the gun-cotton and fuzes has been

already referred to. 160 lbs. of Ashantee powder were procured, and some slow match made, also a number of palm leaf torches. The stone portion of the Palace was examined; it was found to consist of a large building with a flat roof, two stories and in part three stories high, with a strong stone staircase on the outside, ascending to the top. The building enclosed a small rectangular courtyard, the inner portion of which was open, and carried on pillars. It was apparent that what is termed a hasty demolition, would be a failure, owing to the want of powder. The pillars were attacked with the pickaxes, and, being of bad rubble masonry, every second one was soon cut away, the beams of timber supporting the building. Large cuts were made in a similar way in the outer walls, and the powder divided into six charges, placed under the main supports left to the building, which had begun already to settle. The Europeans worked all night.

6th February, 1874.—Lieut. Hare fired the town, beginning from the northern end. The roofs, which were well soaked after the heavy rain, ignited with great difficulty, but once on fire the flames spread rapidly. Lieut. Bell completed the mines, attached the slow match, and fired them; two were seen to explode, and a large mass of the Palace fell. Captain Sartorius, who passed two days after, reported the Palace as completely ruined. The fetish houses and temples were also burned. At 9 a.m. the work of destruction was completed, and the Engineers marched out in advance of the rear company of the 42nd. The heavy rains had swollen the streams across the road; one which was not 6 in. deep when crossed on the 4th, was now 4 ft. 6 in. to 5 ft. deep, and the country all round knee deep in water. The advanced guard had got a tree across the worst portion. By cutting away some trees and branches this was improved a little, and three additional trees were got across in another place, so as to allow the passage to be made on a wider front. When engaged at this place the C.R.E. was ordered to the front, to the Ordah; there the river had risen, and flowed over the roadway of the bridge constructed on the night of the 3rd-4th. On this the army had to cross. It was impossible to repair it properly while the troops were crossing. The piers and bearers stood firm, but the roadway had in places floated up, thus producing holes, through which men fell; something was, however, done to the bridge. The head-quarter staff and the convoys of sick and wounded, the Naval Brigade, 23rd, Engineers, and the larger portion of the Rifle Brigade crossed on it; the reserve ammunition fording the river. A fresh bridge could have been made in about six hours, but this time was not available. At four o'clock the Engineers marched for Agemamue, the Major General directing the C.R.E. to remain and superintend the passage of the river. About five o'clock it became apparent that the bridge would not last much longer, and as the river was rising fast, Sir Archibald Alison ordered the 42nd to strip and ford it. This was safely done, although, as the dark drew on, it was a hazardous operation, the water being up to the men's shoulders.* Large fires were lit on the banks so as to give light. The men crossed in fours,

* The danger arose from the darkness coming on so suddenly, the depth and rapidity of the current, and there being no rope to stretch across the stream to catch a man if taken off his legs.

holding each other's hands; natives who could swim bringing over the arms and clothes, and men with torches being kept on the banks, so as to give as much light as possible. At 8 p.m. the passage was complete, and the C.R.E. started for Agemamue to report the safe passage of the troops to the Major General Commanding.

7*th February*, 1874.—The Engineers, who had bivouacked at Agemamue, marched at 5 a.m. for Amoaful. Lieut. Cotter, R.E., was met on the road carrying a large convoy of sick and wounded men to the rear. Lieut. Bell improved the road, and cut paths round the swamps. At Amoaful shelter for 300 men was constructed that evening. Lieut. Cotter and Lieut. Hearle had made a very strong post of Amoaful, had repaired and made many hammocks for the wounded, and had prepared several hundred tripods for the hammocks to rest on. Captain Butler, who had just come up from the rear, reported to the C.R.E. that the bridge over the Bahrein River, near Kiang Boassue, had been carried away, and that there was 14 feet of water in the river.

8*th February*, 1874.—The C.R.E. marched at 3 a.m. for Kiang Boassue, Lieut. Bell at 4 a m. for Ahkankuassie, the former to repair the bridge, the latter to improve the road. The Engineers were now one day ahead of the troops, and consequently a good deal could be done. The bridge over the Bahrein was replaced, and the road over the swamps re-corduroyed, the old corduroys having been swept away by the floods.

9*th February*, 1874.—The whole of the Engineers moved to Quisah. The road was in good order, some trees that had fallen across it only requiring removal. Shelter for 300 men was constructed at Quisah. That evening a letter was received from Major Jones reporting that the Prah had risen considerably, and that the bridge was in great danger. The whole force marched over the Moinsey Hill next day to Accrofoomue, where the head of the telegraph had arrived. A message was sent to Major Jones to inquire into the state of the bridge and the river. Major Jones's report being satisfactory, the Engineer force halted for the night at the Foomasue River. Lieut. Cotter, with a party, were left at Accrofoomue to dismantle the telegraph after the head-quarters had passed.

11*th February*, 1874.—The C.R.E. pushed on to the Prah, while the Engineers halted at Essiaman. At the Prah, Major Jones had completed and improved the camp, had strengthened the *tête de pont*, and had done much to the place. The bridge, notwithstanding the heavy floods which had been nearly up the roadway, was in excellent order; the gauges attached to the cribs showed that they had not moved, and the whole structure was as good as when it was crossed a month previously.

12*th February*, 1874.—The Engineers marched in from Essiaman.

During the past month, that is since the 1st January, Major Jones had had charge of the line of communications, and under him Lieut. Jekyll was in charge of the telegraph.*

* As a matter of organization. it is desirable to point out that Major Jones fulfilled the duties of what in Germany is called, "Etappen" Engineer. Colonel Colley commanded the line of communications, occupying the position of the German "Director General of Communications," Major Jones being attached to him for Engineer duties.

It will be remembered that the encampments at each station were formed for 450 men, and that the troops had marched up in wings. It was desirable that if possible they should march down by battalions, and so reach the coast sooner than they otherwise would do; the Major General Commanding having at Foomanah intimated his desire that this should if possible be done, the C.R.E. had directed Major Jones to use every effort to construct one additional hut at each camping ground. It was conceived that with the additional accommodation, allowing for men sick, wounded, and on detachment, the battalions might manage to march down complete. Major Jones had carried out his instructions, and each encampment was enlarged by one soldier's hut. Major Jones had also built a new bridge over the Okee, near Mansue, and, favoured by the fine weather, he had converted the Sutah swamps, the old sore, into one of the best portions of the road. He had also converted several of the huts at Prahsue into hospitals, the church at Cape Coast Castle into a hospital, and had done much heavy and important work generally. (*Vide* Appendix XVIII., for Major Jones's report.)

The telegraph, a separate report on which is given in the Appendix I., had got as far as Accrofoomue, 20 miles north of the Prah. The work had not got on so fast as Lieutenant Jekyll had wished, but this arose from circumstances over which he had no control. The line to Dunquah was constructed with materials brought out by him in the Himalaya. Had other materials been then available, the line might easily have been finished, but the telegraph was on board the Dromedary, and did not arrive until the necessity for sending the white troops and provisions to the front became absolute; hence the transport of the telegraph stores was delayed, and the engineer labourers, who, on the completion of the Prahsue encampment, might have been used for telegraph purposes, were required for the still more important duty of carrying provisions. Under these circumstances the telegraph did not make such rapid progress as was desirable. The service it did perform was very great. Had it arrived a fortnight sooner, it might easily have been carried over the Adansi Hills to Foomanah.

During the progress of the work between the Foomasue River and Accrofoomue, a party of men engaged in constructing it were attacked by the Ashantees. Two of the black labourers were killed, and sapper Brooks wounded. The determination and energy displayed by sapper Brooks on this occasion was much commented on. Indeed, had it not been for his resolution in compelling a convoy of carriers to move to the front when scared by the firing, the army would have been seriously inconvenienced.

Major Jones had, during the advance, supported the Engineers in front in every way, by sending up tools and provisions, and during the homeward march, every post and station was found amply supplied with tools, and provisions were waiting for the Engineers at several places. He had further detached two non-commissioned officers and twenty natives to work enlarging and improving the posts at Essiaman and Accrofoomue, where much was done preparing for the return of the white troops.

Although debarred from sharing in the final capture of Coomassie, Major

Jones contributed greatly to the safe return of the troops, and testimony should be here borne to the large quantity of work he performed.

On the arrival of the Major General Commanding, the head-quarters of the 28th Company and 200 labourers marched to Cape Coast Castle; Major Jones was in command, and had received instructions to make as much increased accommodation at the various stations as he could on his homeward march.

15*th February*, 1874.—The Major General directed a small fort to be made at the Prah; this was begun at once, and completed on the 17th, when the C.R.E., Lieut. Bell, and 150 labourers left the Prah, taking double marches to the coast.

The company was at once embarked on board the "Himalaya" and returned to England.

The Telegraph Detachment, closing the various offices in succession, and bringing down the instruments and batteries, arrived at Cape Coast on the 25th.

The whole of the stores were handed over to the Control Department. The C.R.E. and Lieut. Bell embarked in the "Sarmatian" on the 27th, and Lieut. Cotter, with the Telegraph Detachment, in the "Manitoban," on the 4th of March.

The foregoing rough journal of the Engineer operations has been compiled chiefly from the journals kept in the Royal Engineer office at Cape Coast Castle, and the private journals and notes of the various Royal Engineer officers. The sketches are made from rough hand sketches with dimensions taken at the time.

The following remarks on the operations are submitted in the hope that they may be useful; war is fortunately for the English rare, it becomes then of importance to profit by its experience:—

8. The whole of the arrangements for tools worked well, all Engineer material and all intrenching and cutting tools belonging to the army being in charge of the Royal Engineers from the moment they landed.

11. It is desirable that some light bridge should be introduced into the service. The pontoon at present in the service is for many purposes admirable; but it is too large, and too unwieldly, to fulfil all the requirements of war.

Light portable bridges for crossing openings of 30 ft. width in a single span, and light trestles are requisite.

Such bridges need not carry artillery. They need not be calculated to carry infantry crowded in disorganized masses. Although by putting several together, such light bridges might easily be made to carry artillery.

The history of recent wars shows the great want of such bridges. The Bistritz at Sadowa, the Sauer at Woerth, were two streams of very trifling magnitude; yet the want of bridges at the former, and the small number of bridges (11) made at the latter (chiefly of hop-poles), caused much delay to the advancing troops. Colonel Graham, R.E., drew attention to this great want some years ago. So far as is known the want still exists. The trussed girders used in the Ashantee War did their work admirably; they are, however, capable of improvement. United with trestles, a waggon-load would give a very respect-

able number of foot-bridges, and by putting them together would give a bridge over which a gun could pass.

It is a matter much to be regretted that Blanshard's Infantry Pontoon has been allowed to become obsolete, there having been difficulty in getting the five that went to the Gold Coast.* This pontoon was undoubtedly the best for its purpose, although it is quite possible that a better pontoon may be hereafter made. It has worked in all climates; and for a tropical climate, China for example, so far as is known, we have no pontoon, large or small, that we can say will stand the climate. On the Gold Coast all canvas articles were quite useless as pontoons.

The work that the Blanshard rafts did was perfectly wonderful; they were loaded often with men and materials until they were almost under water. They received a great amount of ill-usage, and they were left at the Prah as good and as serviceable as the day they left England.

13. It is essential that whenever Engineers are dressed in uniform like that worn by the rest of the army, some distinguishing badge should be worn. It is requisite to be able to pick out a sapper at once. This was impossible, as all the men wore what was termed the Ashantee uniform. A coloured puggeree on the helmet would have answered all purposes.

14. The traction engine did not come up to expectation. On good roads, with ordinary gradients, it would be valuable; but on the very narrow roads on the West Coast, where no attempt could be made to zig-zag up the road, and where the bridges were of a flimsy description, it was unsuitable as a traction engine. This conclusion was fought against for some time, but at last it became apparent that it could not be trusted to. As a stationary engine it worked very well. While such engines should form a portion of the Engineer's park, yet they should not, in their present state, be counted on as means for transport.

15. In expeditions similar to that to Ashantee, it is very questionable if a one-armed pickaxe and the light field shovel should not be taken in preference to the ordinary pattern. The natives are not capable of handling the ordinary pattern.

The American axes, with the curved hickory helves, worked very well, and left nothing to be desired. The light hand-axes were most useful, and far preferable to the bill-hook.

For some reason the natives disliked the bill-hooks, and invariably broke them.

The naval cutlasses were capital tools, and did their work well.

16. The pack-saddle field-forge worked well. One was taken to the Prah. Leather for mending the bellows should always accompany it. The bellows on one occasion had to be mended with a pair of leather gaiters.

17. A set of cooper's tools in a Clarkson's box should invariably accompany such expeditions; the use of barrels for all kinds of purposes is very great, and they can generally be had.

* The Controller, Royal Arsenal, at Woolwich, is the authority for this.

18. Norton's tube wells were taken to the country. Two were driven, one at Dunquah, another at Mansue, but they were useless. The common pumps attached to the water carts during the Autumn Manœuvres answered all the purposes required.

19. Crease's filters worked very well; they are easily cleaned, and have the great advantage of combining both a tank and a filter. The light galvanized iron tanks sent out for the railway were most useful for the camps.

R. H.

APPENDIX I.

Report on the Electric Telegraph.

2, Morpeth Terrace, S.W.
29th June, 1874.

Sir,—I have the honour to submit herewith a report on the electric telegraph used during the late Ashantee War.

I have endeavoured herein to describe step by step the operations involved in the progress of the line, entering into all details which the peculiar nature of the operations rendered in any way remarkable.

I have also added, at the end, notes upon such branches of the subject as could not be conveniently treated in the body of the report.

At the same time, I have the honour to hand over to you all the original papers connected with the telegraph, consisting of the originals of forwarded, and copies of received, messages, with the whole of the printed paper slips from the instruments, and a few other documents.

I have, &c.,

To Lieut.-Col. Home, C.B., R.E., H. JEKYLL, Lieut. R.E.
Commanding Royal Engineer, Gold Coast Expedition.

The telegraph detachment, consisting of 25 non-commissioned officers and men, with the rest of the 28th company, Royal Engineers, reached Cape Coast Castle in H.M.S. Himalaya on the 9th December, 1873.

At 6 a.m. on the 12th I landed with 15 of these, leaving the remaining 10 on board, it having been decided that the latter should not come ashore for some weeks.

A quantity of telegraph stores brought out in the ship were landed at the same time, and hut No. 4 having been given over for the purpose, steps were taken to house the materials therein without delay.

While the men were engaged in this work, I proceeded to Beulah, distant 9 miles, to procure bamboos for telegraph poles, and found, on arriving at that post, that a large number had already been cut by the natives under the orders of Captain Fowler, 2nd West India Regiment. Of these I purchased 1,500 at 2d. a-piece.

The following day I sent a sapper with 50 women to bring some of the bamboos in, and in the course of the afternoon 100 were deposited close to the telegraph hut. The bamboos being freshly cut were quite green, ranging in length from 16 to 18 feet, and in thickness from $2\frac{1}{2}$ to $3\frac{1}{2}$ inches.

Various plans of fixing an insulator to one of these poles were tried; the best of which, and that finally adopted, was as follows:—

The top of the bamboo was sawn off square, 6 in. above a joint. Four turns of No. 11 wire were twisted tightly round the top, and a plug of soft wood driven into the cavity so as to fill it completely. A hole was bored down the middle of the plug, into which the insulator was screwed.

On the 14th a gang of 50 natives from Moree, with a head man, were engaged as Engineer labourers, and handed over for employment on telegraph work. Of these, 20 were at once set to work to prepare the poles in the way indicated above, and of the rest some were sent to Beulah to fetch more bamboos, others employed in excavating a deep hole at Government House for an earth plate, and in arranging bins, shelves, and other fitments in the telegraph hut.

I had an interview with the Chief of the Staff, and by his directions submitted certain propositions with reference to the construction and working of the telegraph, of which a copy is attached to this report.

On the 15th an instrument and battery were fixed at Government House. A shackle to secure the end of the line wire was fastened to the roof; an earth plate, consisting of 4 ft. of iron pipe, was buried outside, and proper leads of covered wire fixed, to connect these points with the instrument, all connections being soldered.

The iron pipe was planted vertically and filled with water, and every morning water was poured upon it.

At the store hut the 20 natives were fitting up poles, at which they soon became expert, and they continued this work for some days, until upwards of 300 were completed.

In the afternoon the line was commenced. Places having been marked out for the poles through the town, the black men were set to dig holes. They were very inexpert, so much so that each black man required a white one to stand over him and show him exactly how to proceed, and two hours were consumed in excavating the holes to a sufficient depth (2 ft. 6 in.) As soon as this was done, bamboos adapted for the selected situations were brought out and set in the holes, which were then filled in and rammed, the poles being blocked with stones at the foot.

In this manner 7 poles were set, the last one being at the north end of the town, where the bush road commences. A bracket was fixed to the corner of a house 90 yards from Government House, and the wire was brought out and stretched along the ground. The end having been fastened and soldered to the terminal shackle, the wire was swung across a garden, over the bracket and the insulators of the recently-erected poles, then pulled up tight by hand, and lastly secured at the end and bound in at every insulator.

The bamboos behaved well; they were set at distances varying from 60 to 90

yards, and though quite green, were stiff and strong enough to resist the pull of the wire at the slight angles, while at every sharp angle wire stays were provided, by which the pole was relieved from all strain.

Great care was taken in selecting the poles to pick out for angles bamboos which were bent. These were set with the bend opposing the strain of the wire, by which gradually they were drawn straight, the pole being, moreover, set over at a considerable angle.

Bamboos of this sort offered a far more effectual resistance than those which were straight in the first instance.

A few large orange trees in the street interfered with the course of the wire, and had to be cut down. This first day's work was looked upon to a great extent as experimental, to ascertain the capabilities of the bamboos, and was so far successful that no improvement on the method of employment could be devised, and the same intervals and positions were adhered to as long as bamboos continued to be used.

After this commencement, the line was continued from day to day. The road being crooked, and the hills very steep in places, great care had to be exercised in selecting and setting the poles. To diminish the strain of the wire short poles were used at the tops and long ones at the bottoms of the hills, and every pole subject to lateral force was stayed with wire. This was found to be a necessary precaution, for several poles which were left unstayed to test their unassisted strength, after a few days collapsed at the ground line and came down.

The first mile of line was clear of bushes, but these by degrees increased in thickness and height, especially at the tops of the hills, and a gang of men with axes and bill hooks had to be constantly employed in cutting them down, for the road was so tortuous that without an excessive expenditure of poles the line could not be cleared in any other way. The thickest part of these bushes, which did not exceed 20 or 25 feet in height, was just on a level with the wire, and as a rule the quickest plan was found to be to cut them down to the ground.

Three miles from Cape Coast a very dense thicket, continuing for half a mile, was met with. It took an entire day to penetrate this. The poles were set alternately on opposite sides of the road and at very short intervals, whereby the wire was kept as much as possible in the clear space over the middle. But the shrubs met overhead at 10 feet from the ground, and not until the width of clearing had been doubled could a clear passage be made for the wire.

The country after this again became open, and the construction was pursued as before, and continued with tolerable ease to Inquabim Camp, where the first telegraph office was to be opened. Before reaching this place a piece of very thick bush, a few hundred yards in length and overshadowing the road, was met with, but being only a narrow belt, it was easier to carry the line of poles behind it than to adhere to the side of the road, which would involve cutting down a large amount of brushwood, and deprive the road of some shade. I was

unwilling to adopt this plan largely, as it rendered the inspection of the line difficult, so that it was only when serious obstacles arose that the line was permitted to depart from the road side.

On the 22nd December the telegraph was completed to Inquabim, 7 miles, and the first message which passed over the line was sent by Brigadier-General Sir A. Alison to Government House at 10 a.m.

Up to this time the men available for work were 10 sappers and 50 natives. The latter were somewhat difficult to manage. Light work, such as preparing bamboo poles and fixing insulators, they soon got accustomed to, and with supervision did very well, but when it came to digging holes, stretching wire, and cutting trees, a great deal of persuasion had to be used, and the constant presence of white men was necessary to keep them at work. In digging holes they soon gave up spades, and preferred to use pick irons, with which they loosened the earth, removing the loose soil with their hands. While working, the man sat on the ground, and worked between his legs till the hole was as deep as the length of his arm. They tried to shirk getting the holes out to the full depth, and had to be set to work again by the sapper whose duty it was to overlook the excavation and gauge the depth of the holes. They were slow to learn any kind of work to which they were unaccustomed; even the simplest operation, such as uncoiling wire along the ground, they were unable to perform for a long time. In carrying loads, they greatly objected to weights in excess of what one man could conveniently take on his head, such, for instance, as the coils of wire, which weighed upwards of 100 lbs. a-piece. The coils were always slung on bamboos, each coil being borne by two men; but they disliked this method of carriage, and would sometimes take it in turns to carry the whole load, while at other times the coils would be laid down and abandoned by the road side.

Their unwillingness to learn and practice new descriptions of work is probably more due to dense stupidity than to obstinacy; it was therefore found advantageous to restrict them to the merest mechanical labour, and to arrange the gangs so that the same men were continually employed at the same kind of work. None of the skilled or delicate work could be entrusted to them, and their aversion to ladders was such that they could at first seldom be employed off the ground.

Two Sierra Leone carpenters from the workshops at Cape Coast were far superior in intelligence, and soon became skilful in manipulating the wire and binding it to the insulators, work from which it was a great object to save the sappers to some extent, owing to the excessive exposure to the sun which it entailed.

The native labourers were moreover extremely timid. Many deserted after seeing some old bullet marks in a tree, others after being knocked down by lightning shocks when handling the wire. This incident was productive of some good, inasmuch as it inspired great respect for the wire, which was henceforth regarded as Fetish, and never molested by the natives.

Several times in December the work had to be stopped for part of a day

owing to thunder storms, which caused such strong induced currents in the wire that it was impossible to touch it.

At Inquabim a wooden hut built for the surgery was used as the telegraph office, for being so close to Cape Coast it was not worth while to build a hut on purpose, and an office would not be kept constantly open. But in order to afford means of placing an instrument in circuit at any time on the shortest notice, a strong pole of hard wood was planted in front of the surgery, to which the wire was shackled. From this pole a short span of two wires was run to shackles fixed on the roof of the hut, and leads of covered wire completed the connection with the bench on which the instrument stood. From the hut 100 yards of bare wire was run out to a neighbouring swamp, in which an earth plate similar to that in use at Government House was sunk.

The leads remained permanently fixed, but when no instrument was in circuit, the wire was put through by bridging over the shackles outside the hut.

The line worked well between Cape Coast and Inquabim with 10 cells at each end, and the tests for insulation and conductivity were as good as could be desired. The conductivity-test was good enough to satisfy me as to the excellence of the earth connection at Government House, where the soil looked so dry that I was apprehensive of failure, and was preparing to place an earth plate in the sea had the resistance proved too high. Fortunately no difficulty on this account was experienced throughout the operations, and at most stations good earth was easily found.

The construction of the line was pushed on as speedily as possible, bamboos continued to be used, and their capabilities were now thoroughly understood, while the men were organised and drilled to their work, so that the rate of progress increased. During the construction of the pole line, they were divided as follows :—

	Sappers.	Natives.
Laying out and digging holes..	2	10
Cutting trees	2	20
Setting poles and staying	2	10
Running wire	3	10
Superintending	1	—
	—	—
Total	10	50
	—	—

The numbers of men varied from day to day as well as the nature of the country, so that precisely the same distribution of labour could not always be adhered to, but the above statement represents the general organization of the working party.

The transport of materials was undertaken by the Control Department, from whom was demanded each day the number of carriers required for the next. Every morning, by the time the carriers were told off, the stores for the day were laid out in loads of the proper weight, and labelled with their destinations, in front of the telegraph hut, so that no delay took place in starting the carriers

off. It was intended in this way to make small depôts of stores at all the camps on the road, from which materials could be drawn as required and laid out by our own labourers. This was found more convenient than attempting in the first instance to distribute materials along the road.

Two miles beyond Inquabim, and shortly before reaching the village of Assayboo, trees were first met with of which the trunks were suitable for the attachment of the wire. Small galvanized iron brackets held the insulators. The bracket was attached by 3 nails, and is the best form of tree or wall attachment with which I am acquainted.

The brackets were generally fixed at heights of 15 ft. to 18 ft. from the ground, according to the inclination of the ground and the lengths of the neighbouring bamboo poles, and endeavours were always made, when passing from a tree to a pole, to arrange the height of the bracket so as to relieve the pole from strain as much as possible.

For the next 5 miles, up to the camp at Acrowful, brackets and poles were used in about equal numbers; the bush became more dense, and the axe party had to be strengthened to keep pace with the rest. When using tree attachments the progress of the line was slower than on poles, owing to the quantity of undergrowth requiring cutting, and the trouble of threading the wire through the thick places; and although every exertion was made, by strengthening the gangs upon which the heaviest work fell, to accelerate the advance, it was seldom that more than 2 miles of work could be completed in a day.

At this time the number of labourers was raised to 80; 50 fresh hands had been provided for telegraph work at Cape Coast, but of these the greater number were boys, and I was compelled to reject 20 of the smallest, who being less than 4 ft. high were really of no use.

With only 10 sappers available for work in the field, a larger number than 80 could not well be controlled and directed; no more were therefore engaged until the remainder of the telegraph detachment landed at Cape Coast.

There was necessity for great care in selecting trees for attachments, and I knew by experience that the danger to which a line of this sort is subject is fracture of the wire caused by the trees swaying in wind. For this reason all palm trees were avoided and medium sized trees generally, and only those made use of which, either from their great size were secure from swaying, or were small enough to be cut off immediately above the insulator, and so stand as a pole rooted to the ground.

Some trees were covered with parasites and creepers to such an extent that it would have been too laborious to clear them; the texture of others was soft and spongy, affording no hold for nails; while others were full of ants' nests and so infested with insects that men were unable to work upon them. With these, in addition to principal and minor considerations in view, the selection of suitable trees required care, which it was the more necessary to bestow as it was foreseen that the delay in repairing portions of the line would be great should it fail, especially if it failed at a distance from a camp.

On the 26th December the instrument and battery at Inquabim were removed

to Acrowful and connected up there. Communication with Government House was kept up, and daily tests were taken which shewed the electrical condition of the line to be satisfactory. The arrangements of the terminal pole and office were the same here and at other temporary offices to those at Inquabim already described. The wire was extended towards Dunquah 6 miles, the system of construction remaining the same, but the bush was more dense and very few bamboo poles could be made use of. Groves of bamboos of immense size had to be cut through, whereby some time was lost. Had covered wire been obtainable at this time, I should certainly have used it in such situations in short lengths, leaving a small working party to make good the open line and remove the covered wire when completed, thus admitting of the main working party proceeding without delay and without losing communication.

As soon as Dunquah was reached on the 30th of December, the instrument and battery were removed from Acrowful, and set up temporarily in a tent, while a hut was being built for their permanent accommodation; for the importance of Dunquah and its distance from Cape Coast (twenty miles) were such as to warrant the establishment of a permanent office.

It now became necessary to consider what steps should be taken for the maintenance of the line, and for this duty it was decided to post one sapper at every 20 miles, and to leave with him a supply of tools and stores, and four or six native labourers, according to the nature of his section. A sapper had already been established at Cape Coast for this work, and was daily engaged in examining some portions of the line, improving weak places, tightening stays, and cutting back the creepers and shrubs. He was always accompanied by his four men carrying the tools and a step ladder.

Another sapper was now posted at Dunquah, and his first work was to build a hut for a telegraph office, in which also he himself and the sapper who worked the instrument should live. In two days' time a substantial hut, built of bamboos and roofed with palm leaves, was built, 10 feet long by 6 feet wide, furnished with a bench for the instrument, a seat for the clerk, and standing bedsteads for the clerk and lineman, these bedsteads being also constructed of bamboo tied with wire. The battery stood under the bench, and a small test box, which was made at Cape Coast, was fixed to the wall to facilitate changes of connections.

When the hut was finished, the lineman began his regular duty, and being in constant communication with the man at Cape Coast, they so divided their time that every part of the line was visited by one or the other every second day. Throughout the pole-line little had to be done, but among the trees continual cutting was necessary to keep the line free from creepers and the fast-growing tropical plants, which from their succulence, would have seriously interfered with the working of the line, had they ever been permitted to come in contact with it.

Near Cape Coast, much of the work consisted in the renewal of the pickets to which stays were attached, and which were eaten through by ants in the course of a week. Where practicable, the stays were made fast to bushes.

The line was now extended to Yancoomassie, four miles, and having still only one instrument and battery besides those at Cape Coast, the office at Dunquah had to be shut up pending the arrival of the regular telegraph stores, in order to open work at the terminal station.

Up to this time the works had been entirely carried on with tools and materials supplied by the Telegraph Department of the General Post Office, and put on board the Himalaya in great haste just before her departure from Plymouth. The materials were as good as possible, the tools not sufficiently numerous, and some partly worn. But the importance of having these stores, and the wisdom of sending them in the same ship with the men, cannot be overstated, for as it turned out, owing to difficulties in obtaining transport and labourers, the telegraph could not without them have been up in time to be of use.

It certainly is much to be regretted that the whole telegraph equipment did not arrive at the same time, for during the whole latter half of December plenty of labour was procurable both for work and transport. Then the stores could have been carried up the country, and deposited in sufficient quantities at the various camps all the way to the Prah, and there would have been abundance of tools as well as materials for the employment of the whole detachment of telegraph men. Nine sappers, however, out of the 19 available for construction having been left on board ship for three weeks, the work of the telegraph could only go on at half power. The loss of this precious time was never recovered. The telegraph, instead of keeping pace with every advance of the army, as it obviously should have done, was ever dragging painfully behind, and ultimately only attained to a point 50 miles from Coomassie.*

On the 31st December, by which time the end of the line had nearly reached the camp at Yancoomassie (Fanti), H.M.S. Dromedary, with telegraph stores on board, arrived at Cape Coast. The stores brought out in the Himalaya were almost expended, and the working party nearly at a standstill, their employment consisting principally in clearing bush for the extension of the line to Mansue. (*Vide* Appendix XVI.)

Receiving the news of the ship's arrival by wire at Yancomassie, I hastened down to the coast to make arrangements for the speedy landing of the much-needed stores, and their transmission up the country.

The whole of the stores were disembarked in the course of four days, and arranged in or about the telegraph hut.

The troop ships also arrived at the same time, and on the 1st January the first half battalion landed and marched to Inquabim. The 28th Company Royal Engineers came on shore the same day, and with them the remaining 10 men of the telegraph detachment, comprising 9 constructors and 1 clerk. These were retained for a few days at Cape Coast, to assist in landing and arranging the stores.

And now commenced the transport troubles. Up to this time transport had been abundant, and it was of stores only that we were in want. Now the situa-

* *Vide* Appendix for correspondence on this subject. The advantage that the Post Office material was to the expedition was incalculable.—R.H.

tion was reversed, stores were in profusion, but there lacked the means of conveying them up the country.

Each morning succeeding that of the 1st January, half a battalion of troops came ashore, and marched up with its transport-train complete. The supply of provisions for advanced posts could not be checked, so the drain of carriers for these services left no transport available for the conveyance of telegraph stores.

Vide attached correspondence, marked F.

Thus matters went on till the 5th January, the day on which the landing of the 23rd Regiment was commenced. Every day I had urgently pressed the Control Department to provide carriers, but except on the 1st, when a few loads were sent up, my demands could not be complied with. On the 5th January, however, 150 carriers were told off at 2 p.m., and a large number of loads having been kept prepared for several days, they started off in a few minutes. A like number was promised for the following day. At 5 p.m., three hours after starting, the whole of these carriers re-entered the store, loads and all.

The men provided to carry the baggage of the 23rd Regiment had deserted, and my carriers were re-called by order of the Brigadier General to take their places. Two days later, when the movement of the 23rd had been counter-ordered, carriers were at length found, and a large quantity of stores sent to Mansue; this was followed by further supplies to the stations beyond, until a sufficient quantity had been laid out to enable the telegraph to reach Prahsue, and all immediate anxiety on this head was at an end.

Meanwhile, in order to preserve the working party from the absolute inaction which was threatening it, I was endeavouring, by the authority of the C.R.E., to raise carriers and labourers on my own account, and in the course of the eight days which followed the arrival of the Dromedary succeeded in collecting and despatching three gangs of 25 men each, under intelligent head men. There was much difficulty in getting these men, as I had to compete with the Control Department, by whom, apart from their special facilities, large rewards for men were being offered.

These 75 men carried up the stores and tools of which the working party stood most immediately in need, and also instruments and batteries for the office at Dunquah, which was re-opened on the 5th January. On arriving at Mansue they were attached to the working party, with which they remained and continued to be paid as Engineer labourers.

Three offices were now at work, and the battery power was raised to 20 cells, to overcome the increased resistance.

The working party having reached Yancomassie on the 31st January, pushed on through bush of ever increasing thickness. Up to Mansue, 12 miles distant, there were few open spaces were poles could be used, and the line was carried almost wholly on tree attachments. Many of the original labourers had by this time deserted, and though I gave orders to the non-commissioned officer in charge to collect as many able-bodied men as he could at the villages on the road, he could scarcely do more than keep up the original numbers of the gang, which, until the arrival of the men from Cape Coast, had never as yet exceeded

80. The sappers, however, were strengthened, and when the wire reached Mansue on the 8th January, the 25 men composing the telegraph detachment were distributed as follows :—

Clerks—2 at Cape Coast, 1 at Dunquah, 1 at Mansue, 2 with working party	6
Linemen—1 each at Cape Coast, Dunquah, and Mansue	3
Unpacking and despatching stores at Cape Coast	2
Permanently disabled by fever	1
Working party, including Non-commissioned Officer in charge	13
Total	25

Thirteen would not really represent the strength of the working party, for a month's exposure to the sun was now beginning to tell upon their health, and every day some of the men were unable to work, owing to attacks of fever. But only one serious case had as yet occurred, and the men were seldom off the works for more than 2 days at a time. The distribution of the working party was at this time somewhat modified, to cope with the thick bush. The trees for attachment having been picked out, an axe party of not less than 40 cleared the bush just sufficiently to allow of the wire being threaded through. Next followed a gang fixing insulators, then another with the wire, which after being run out was raised on to the insulators and pulled up tight and then bound in. Lastly another axe party cleared the wire by cutting down bushes in contact with it. Endeavours had been made to increase the rate of progress by dividing the working party, but it did not answer, as the numbers were too small to work with advantage.

The section from Mansue to Sutah, 11 miles, was finished on the 12th at 6 p.m.

Yancomassie (Assin), 12 miles, was reached on the 17th. Here a permanent hut was built, and a lineman posted, as at Dunquah, but the office was not required to be kept open at this time.

Barraco, 6 miles further, was reached on the 21st, and Prahsue at 8 p.m. on the 24th.

There were now 4 offices in circuit—viz., Government House, Dunquah, Mansue, and Prahsue, and the line worked well with battery-power of 30 cells. The earth-plate was sunk in the Prah, and signals were better than at either Barraco or Yancoomassie, where the earth was less good than in most places.

At this time I was invalided home from Cape Coast, after repeated attacks of fever, and I embarked on the 26th January.

The line was extended to Essiaman, 11 miles from Prahsue, on the 2nd February, and by the 8th reached Accrofoomue, 12 miles further.

After the end of January, thunderstorms began to be very frequent, and every thunderstorm broke down the line, by causing the insulators to fail.

After every storm numbers of these were found broken, having split and fallen off the bolts, allowing the wire to fall to the ground. So extensive was the damage between Mansue and Prahsue that the linemen were totally unable to cope with it; moreover, at this time the lineman at Yancoomassie fell sick and

was unable to work. The consequence was that communication was suspended from 3.45 p.m. on the 5th to 11.30 a.m. on the 8th, and as it was useless to extend the wire further to the front under such circumstances, Captain Jones ordered the working party back, and distributed the men along the line, two at each camp, to repair the damage, and endeavour to maintain the part already constructed in working order. The failure was entirely due to the spike insulators—where Post Office insulators and brackets had been used, the line remained in good order.

Before leaving Cape Coast, I had sent to ask the Chief of the Staff whether the line was to be extended beyond Prahsue, for at that time it was supposed that the war was over, and it was not anticipated that there would be fighting. Hearing in reply that the line was to be proceeded with, I sent up fresh supplies of stores to the Prah.

By the afternoon of the 8th February the repairs of the line were finished, and work was carried on from five stations. From this time till the close of the war no further interruptions occurred.

The offices were closed on the 23rd February. The instruments, batteries, and unexpended stores were brought down to Cape Coast, packed, and handed over to the Control Department.

Message books, original messages, and the whole of the instrument slips were packed in one box and brought home.

The detachment embarked on the 4th March.

I am convinced that the value of a line of telegraph depends greatly upon its being thoroughly reliable. If it is a matter of uncertainty whether at any particular moment communication is or is not open, a telegraph is of little practical use. To be entirely free from occasional interruption is not possible, but with proper precautions and care in construction, the preventible causes of interruption may be so guarded against as to render their occurrence at the most improbable. Throughout the operations I looked upon this principle as of the first importance, to which every other consideration should be subordinate. The line might have been pushed forward at a greater rate, by adopting a less careful method of construction ; but had this been done, it must have failed after a short time, and then workmen would have been at a distance, and the delay as well as the labour of reconstruction would have been alike disastrous. I therefore spared no pains to erect the line in such a manner that no preventible accident should occur to interrupt its steady work.*

Unsatisfactory as this telegraph turned out to be in many respects, and frequent as were the interruptions, it is worthy of remark that no cause of failure traceable to want of skill, caution, or foresight on the part of those concerned in its construction, arose during the whole time the telegraph was in use.†

* In this Lieutenant Jekyll fully succeeded. Too much praise cannot be given for the way in which this line was made. Lieutenant Jekyll fully guarded against all accidents over which he could possibly exercise any control.—R.H.

† I consider the telegraph was by no means unsatisfactory. I fully concur with Lieutenant Jekyll that all that human knowledge or labour could do was done to make it succeed.—R. H.

I have great pleasure in bearing witness to the uniformly good behaviour of the men composing the telegraph detachment. The work which they had to perform was very severe, the difficulties to be overcome almost unexampled, and though many were suffering at times from the effects of climate, all continued to work as long as they had strength. Serjeant Langstaffe and Serjeant Dowie were particularly active and zealous in their duties, which they carried out in a way which left nothing to be desired.

Once the working party was fired upon, and one man (Sapper Brooks) wounded. This was the only occasion that any molestation from the enemy was met with.

Attached is a short statement of progress from the commencement to the end of the operations.

H. Jekyll, Lieutenant, R.E.

Statement of Progress.

12th December.—15 of Telegraph Detachment landed. Poles bought at Beulah and stores landed.
13th „ Poles brought in; arranging stores.
14th „ Preparing poles and office at Government House.
15th „ Commenced line.
22nd „ Office opened at Inquabim.
26th „ „ „ Acrowful.
30th „ „ „ Dunquah.
31st „ „ „ Yancoomassie. Dunquah closed. H.M.S. Dromedary arrived at Cape Coast.
1st January.—Troop ships arrived, and remaining ten men of Telegraph Detachment landed. Commenced to land stores from Dromedary.
5th „ Re-opened office at Dunquah.
7th „ Sent up stores to Mansue; delayed since 1st January by want of transport.
8th „ Office opened at Mansue.
12th „ „ „ Sutah
17th „ „ „ Yancoomassie (Assin.)
21st „ „ „ Barraco.
24th „ „ „ Prahsue, working with Dunquah, Mansue, and Cape Coast.
27th „ „ „ Office at Dunquah closed.
2nd February.—Office opened at Essiaman.
7th „ Working party fired upon near Accrofoomue.
8th „ Office opened at Accrofoomue, and Essiaman closed; five offices working.
8th „ Working of line interrupted since 5th by breakage of insulators.

21st February.—Five offices still working. Essiaman and Yancoomassie (Assin) closed.

23rd „ All offices closed. Instruments and batteries brought down to the Coast. Line left standing.

Materials.

The construction of the telegraph line from Cape Coast to Yancoomassie (Fanti) 24 miles, was as described in the Report, carried out with materials brought out in H.M.S. Himalaya. They were put on board, I believe, at the instigation of Major Webber, R.E., and were principally supplied from the stores of his division in the Postal Telegraph Department. They consisted of stores and tools of the descriptions ordinarily in use in that department, the patterns of which have been arrived at after years of experience and improvements.

A complete list of these stores is attached.

Besides the known excellence of these materials, a further and noteworthy advantage in their employment was, that the men who were to use them, having been trained in the Postal Telegraph Department, were familiar with them, and understood their capabilities.

It is impossible to speak too highly of the value of these stores. They were the salvation of the telegraph. The insulators and brackets were especially valuable. The shape of the former was such as to admit of their being readily adapted to the bamboo poles, and being made of white glazed porcelain, they were well suited to resist the blazing heat of a tropical sun. The brackets made admirable tree attachments, and kept their places in a manner which left nothing to be desired. A man on a ladder could fix his bracket on any part of the tree within reach of his arms, requiring no tool but a hammer, and the nails by which it was held could be hammered into wood of any hardness. Nothing more than this had to be done except when a tree was met with of which the bark was thick and soft, in which case a few strokes of a hand axe were sufficient to expose part of the hard wood; or when it was very small, it was a good plan, in addition to the nails, to bind the bracket to the tree with three or four turns of No. 11 wire.

The batteries were ten-cell Leclanché, of the common Post Office pattern, provided as usual with terminals, which made them handy to use in the offices.

The instruments were ordinary pattern Direct Writers, as used by the Post Office, which can hardly be improved upon.

The supply of tools was scarcely sufficient, but a larger number could not be furnished at such short notice.

Of the stores forming the principal part of the telegraph equipment, and brought out by H.M.S. Dromedary, some were also excellent, especially the tools, of which the abundant supply and admirable quality were of the greatest service.

A. The wire was the same as that supplied by the Post Office, if anything of better quality, and I venture to express an opinion that a better wire for military telegraphs than No. 11 galvanized iron, weighing 2 cwt. to the mile, could

hardly be selected. Its strength and conductivity are ample, it will make stays of any required strength as well as the line, and is moreover very useful—and in the present case was used—for many engineering purposes foreign to the telegraph.

A large quantity of a new kind of wire, composed partly of steel and partly of copper, was sent out later in the transport Thames, but I did not think it advisable to have it landed. The ordinary wire fulfilled every requirement, and I was unwilling to incur the risk of a doubtful experiment, being myself, as were also the men, ignorant of the capabilities of the new material, and having neither time nor opportunity to give it a preliminary trial.

B. There were also drums containing half a mile each of covered wire; three of these were used, more would have been made use of had the drums been lighter. A smaller wire would have answered the purpose.

The batteries were Leclanché 10 and 20 cell, very similar to the Post Office pattern, but not fitted in proper battery boxes, and somewhat inconvenient for want of terminals. They gave a very good current and demanded little attention.

C. Two kinds of instruments were sent, Military Direct Writers, and Magnetic Alphabetical Instruments; the latter were not unpacked. I knew that they could not be used owing to the numerous and violent thunderstorms. I have known as many as twenty instruments of this class, though armed with lightning protectors, put *hors de combat* by one storm in the Eastern Counties. When affected by this cause, a skilled mechanic is required to repair them. They fail, moreover, on a line either long, or of which the insulation is imperfect.

The Direct Writers were not unlike those supplied by the Post Office. They were smaller and scarcely so convenient to work, but still were very good instruments.

Relays and double current keys were also supplied. They would have been very useful if the insulation had fallen very low. It was, however, good enough to allow of five instruments being worked in circuit with a single current, so there was no object in bringing them into use.

The galvanometers were of three kinds, astatic, detector, and three-coil. The latter appeared to be out of order,* but as they are not required for telegraph work, no use was made of them. The detectors were good instruments of the usual kind, and every lineman was provided with one.

One astatic galvanometer only was used in connection with Wheatstone's Bridge. I retained this instrument myself, and found it a very good one, and when invalided, I gave it in charge to Corporal Kenney, who alone of the detachment understood its use.

D. The least successful part of the equipment were the experimental insulators. These were not good either in design or construction, and the fact of their having been used with success for the greater part of the line is due to the skill and patience of the men. The design of the insulator was faulty in the follow-

* This was not the case. The appearance was caused by the magnetic dip.

ing respects. The shank was too long by at least half, the wire thereby acquired an unnecessary amount of leverage, the result of which was in some instances to loosen the hold of the spike. Moreover, it had on this account to be made of thicker iron than would otherwise have been necessary. The end of the spike was sharpened to a broad point, and so fashioned that when used with the insulator upright the broad edge cut aross the grain of the tree instead of cleaving its way. Consequently the spike would only admit of being driven into the very softest kinds of wood, and in the great majority of instances auger holes had to be bored. The necessary use of augers is a disadvantage of greater weight than might be supposed. When a man is on the top of a ladder an auger is a very awkward tool to use, and to use it at all the man must be opposite the place where he wants to bore the hole. Now it very frequently happened, owing to the buttresses of the cotton trees or bushes growing at the foot, that a ladder could not be planted in the required place, and in consequence of this many insulators had to be fixed in inferior situations. With brackets, as pointed out above, this is not the case. (*Vide* Pl. XXXII.)

The slit provided in the head of the insulator for the reception of the wire was inconvenient in many respects, and was a source of weakness. An external groove would be much better.

The principal defect in the construction of the insulator lay in the cement with which the ebonite cup was fasted to the iron bolt. This cement appeared to pulverize, or for some reason failed to adhere. The practical result was that a very large proportion of the cups were loose. Many fell off while being unpacked, others in transit, and others after being fixed in position, especially at angles and points subject to unusual strain.

Whether this failure was partly due to the heat of the sun, intensified by absorption by the black cup, I am unable to say ; the fact remains that cups originally firm became loose upon the trees, and detached themselves from the bolts, thus allowing the wire to fall to the ground. and much of the work of the linemen consisted in replacing insulators which had failed in this way.

The ebonite was weak, for in attempting to drive the spikes, even into auger holes, the cups would often split with the concussion and fall off in two pieces.

The effect of thunderstorms upon the insulator was remarkable. After every storm a number of cups split and fell off—the wire of course coming to earth—and as thunderstorms were of frequent occurrence after the end of January, the damage was so extensive that the whole working party had to be employed in maintaining the line and replacing these broken insulators, and its further advance was of course stopped.

The cause of failure may be due to the weakness of construction of the insulator being unable to resist the slight tremor of the trees, or possibly to lightning in the wire passing to earth through the cup and splitting it in its passage.

I think it doubtful whether ebonite is to be recommended as a material for insulation for use in the tropics. It might be an improvement to paint them white.

The stores were well packed. The armatures of the direct writers were

slightly bent by the regulating screws, otherwise the stores came without accident.

E. As regards their arrangement, it would have been better if the weight of the separate packages had whenever possible been kept down to 56 pounds. The Control stores received at the same time were arranged so, and were thus able to be sent up the country without delay as soon as they were put on shore.

The boxes of telegraph stores were mostly large, and they had to be opened at Cape Coast and repacked for travelling. The natives had such an objection to sharing a load which was too heavy for one, and so often abandoned such loads by the roadside, that everything was as far as possible arranged in single loads. The insulators were slung on bamboos in rows, and each bamboo was carried by two men; they did not mind these loads as they were purposely made light, but they would not have carried the insulators in their own boxes. If the stores had been in smaller boxes, some unpacking would have been saved to get at necessary articles, which were stowed in the same boxes with things not required.

F. The stationery was all together; it would have been more convenient in small quantities, each package containing an assortment suitable for the equipment of an office.

Before leaving England, I had requested that the contents of each box might be plainly marked outside, and on every article "Telegraph," in large letters. These precautions were useful in preventing the stores from going astray. It would have been a great convenience if an invoice of the stores had been sent by the previous mail.

G. For want of some intimation, I was unaware that the special insulators sent in the Thames were of a different pattern from the first batch, so that I did not have them landed, having a sufficient number of the others on shore. Since returning, I have seen this insulator, which, though I do not approve of it, might have been better than the other, and was certainly worth a trial. It differed from the other in having the shank turned down, and being bored with two holes for nails, otherwise it was the same in every respect.

Men.

H. The detachment was composed, as before stated, of 6 clerks and 19 construction men; total 25. A nominal list is attached.

The whole of these men had been trained in telegraph work in the service of the Postal Telegraph Department, under Major Webber, R.E. Most of them had been for upwards of three years exclusively engaged in this work, and all were thoroughly proficient in the duties they were called upon to perform.

Of the six clerks, two came direct from the telegraph office at Birmingham, two from Ipswich, one from Major Webber's office in London, and one from the Postal Telegraph Stores at New Cross.

Six was too small a number of clerks to work this line of telegraph properly, and the work fell very heavily upon them, as for the most part each clerk had entire charge of an office, and was available for duty night and day. Twelve

would not have been too large a number for the duty, allowing for proper reliefs.

As an instance of the condition to which towards the end of the operations they were reduced, I extract a note written by the clerk at Cape Coast on the counterfoil of one of the message books.

"Note to explain writing. 21st February, 1874.

"On 20th February was laid up with fever, could not keep my head up, but could manage at times to send, and also read slip while lying down.

"One of the West India Regiment, an orderly, wrote a greater part of the messages. The messages I find are all right, but badly spelt."

The same clerk (Corporal Brown) had suffered from several previous attacks, when he had been assisted by the lineman, and in the early time had shared the duty with another clerk. But this man was sent into hospital in the middle of January, and the lineman was laid up shortly after.

The clerk at Mansue was also disabled by fever before the end of January, and his place was filled by the lineman, who had sufficient knowledge of instruments to read the slip.

I. I venture to make a few remarks upon this subject, which the experience of the Gold Coast suggests.

It is essential to the efficiency of a line of telegraph to have thoroughly trained and proficient clerks, who must in addition to their special knowledge be conversant with the maintenance of a telegraph office, and with ordinary testing. Every clerk must be able at once, on the occurrence of a fault, to determine whether it is due to a break down of the line, or to some defect or accident in his own apparatus.

Clerks cannot keep up to the requisite standard of efficiency without constant practice. Hence the system of training clerks in Postal Telegraphs is of incalculable value, as the same experience could hardly be gained in any other way. There is one consideration, however, which it is important to bear in mind, viz., that after long-continued employment in telegraph offices, especially in large towns, men lose that robustness of health which is necessary to enable them to withstand the hardships of campaigning, In this detachment, for example, the contrast was very apparent between the men who for three years had sat in telegraph offices, and those who for the same time had been engaged in the open air on works of construction and maintenance. It would, therefore, I venture to think, conduce to the efficiency of the service, if military clerks, while continuing to work in the Postal Telegraph Offices during the greater part of the year, were removed for three or four months in each year, and employed upon maintenance works, where, in addition to keeping themselves in good health, they would acquire that kind of experience which it is of the utmost importance that they should have.

The construction men were also, thanks to the training they had received in England, so familiar with all the details of their work, that they were at once able to take up their several duties, and to make the most of the materials with which they had to deal. The men told off as linemen, had been linemen in Eng-

land, and understood how to test and search for faults, of which, in the course of the operations, many (caused for the most part by falling trees) had to be removed.

The special training of these men is quite as important as that of clerks, and, as in their case, can only be gained in the Postal Telegraph Department. A year at least is required to convert a good artizan into a telegraph constructor, and a year and a half to make a lineman.

It is useful for linemen to have a sufficient knowledge of instruments to enable them to transmit and receive messages slowly.

Offices and Stationery.

K. The instructions to clerks, of which a copy is attached, explain the working of the offices.

The want of a convenient office-equipment was the cause of considerable inconvenience, and the absence of clocks, of which none were sent out, was very much felt. A clock was with some difficulty procured from the Control Department for the use of the office at Government House, and messages sent over all parts of the line had to be timed by it, involving frequent messages from all offices to Cape Coast for time alone.

A convenient arrangement for a military telegraph office would be a strong box, fitted with compartments for stationery and the requisites of an office, of a compact form, and provided with lock and key. Such a box might be designed to include a clock, test box, and galvanometer, and as a receptacle for copies of messages and instrument slips.

L. The message forms used were those designed for army signalling use. Though good, I venture to think them capable of improvement, especially in the method of keeping the copy of received messages. There is less liability of error if the office copy and the sent out copy are written simultaneously with the assistance of a sheet of blackened paper, instead of the former being copied on to a counterfoil.

M. In order to make a distinction between ordinary messages and messages of great importance which must on no account be delayed, the forms in a few of the message books were marked with the words "Special message, to take precedence," and were reserved for the use of the Head-quarter Staff. It would be useful to have a form for this purpose and for engineering messages relating to the condition of the line printed in colour, or on a coloured paper.

Another form (specimen attached) was printed at Cape Coast for the speedy information of all Commanding Officers and Heads of Departments, of changes of offices, and of the stations with which communication was open. These forms were sent out from every office on the line as soon as any change or extension was made.

Office diary books of a simple form should be introduced into the telegraph equipment. For this purpose I had sheets of paper bound up into rough books, one of which was sent to each clerk, together with instructions for its use, of which a copy is attached.

The number of messages sent and received over the line cannot be given, some

of the office diaries having been lost. From those which are preserved, the following figures have been extracted:—

	Received.	Forwarded.	Total.
Government House, 22nd Dec. to 23rd Feb.	617	480	1,097
Dunquah, 5th January to 27th January	160	160	320
Yancoomassie (Assin) 14th Feb. to 18th Feb.....	51	74	125

INSULATION.

N. Between Cape Coast and Dunquah, where none but porcelain insulators and brackets were used, the insulation was uniformly good. During the day the amount of loss was generally inappreciable on a galvanometer, and the resistance, as measured by Wheatstone's Bridge, exceeded 2,000,000 units per mile. The resistance of the conductor was 26 per mile. During the night moisture caused a slight loss. There was never sufficient leakage to interfere with the working.

Over the rest of the line where the spike insulators were used, the insulation was very variable, depending upon how many of the cups were broken. This disturbing cause vitiated the test, so that no reliable result could be arrived at. Between Mansue and Prahsue the difference between the insulation and conductivity tests on a common detector seldom exceeded 10° to 15°.

The conductivity was good throughout, averaging 25 units per mile.

FAULTS.

28th Dec., 1 p.m.	30th Dec., 11 a.m.	Disconnection. Tree falling across wire at Inquabim. As soon as this was repaired, another tree fell at Acrowful, and continued the interruption.
11th Jan., 11.20 a.m.	1.30 p.m.	Disconnection. Tree falling at Acrowful.
13th Jan., 6 p.m.	14th Jan., 6 a.m.	Earth and disconnection. Tree falling 5 miles south of Mansue.
15th Jan., 7 a.m.	9 a.m.	Earth. Tree falling north of Acrowful.
20th Jan., 6.30 a.m.	7.30 a.m.	Disconnection. A tree to which a bracket was attached was burnt, and wire severed.
1st Feb., 4.30 p.m.	2nd Feb., 1 p.m.	Earth. Pole near Dunquah broken by fall of a tree.
3rd Feb., 11.15 a.m.	4th Feb., 11.15 a.m.	Earth. Wire on ground between Mansue and Prahsue, owing to failure of insulators.
6th Feb., 3.45 p.m.	8th Feb., 11.30 a.m.	Earth. Wire on ground in many places between Prahsue and Mansue, owing to failure of insulators. Whole party recalled to repair damages.

CORRESPONDENCE, &c.

A.

The Colonel on the Staff.

Cape Coast Castle, 14th December, 1873.

The detachment of telegraphists consists of 25 men, of whom 6 are operators and 19 constructors.

With the latter, and the assistance of 100 natives, I expect to construct the line at the rate of five miles per day, though I cannot speak with certainty till I have had the experience of two or three days on the road.

With 6 operators it will not be safe to reckon upon keeping more than three offices constantly open. I beg to make the following suggestions:—

That a single wire only be erected. Two could be run with perfect ease, but the number of clerks is not sufficient to work more than one, and a single wire is less likely to suffer interruption. (Approved.)

That three telegraph offices be established and maintained—

(*a*) At Government House, Cape Coast Castle, permanently. (Approved.)

(*b*) With head-quarters shifting from place to place, and following the movements as quickly as possible. (Approved.)

(*c*) At some other generally intermediate point whichever happens to be the most important. (Approved.)

This office to be closed and re-opened elsewhere, according to requirements.

Instruments can be kept fixed at three or four principal posts on the road, and any one can be put in circuit when required, so that to shift the acting office will only involve moving the clerk. (Approved.)

Message forms of two kinds should be provided.

(*a*) For ordinary messages, with which Heads of Departments at all posts, whether provided with telegraph offices or not, should be supplied. (Approved.)

Messages written on these forms to be transmitted in the order in which they are received. (Approved.)

(*b*) For special messages for the use of the head-quarters only, which will take precedence of all others. (Approved.)

That ordinary messages be transmitted only between the hours of 6 a.m. and 6 p.m. (Approved.)

That one telegraph clerk be permanently attached to head-quarters, whose duty it would be to take charge of the instrument and batteries while moving from place to place, to fix and connect the same on arrival at each post, and to receive and transmit the messages. A second clerk to be permanently stationed at Government House for similar duties. The remaining operators and constructors to be disposed of according to the requirements of the service by the officer in charge of telegraphs. (Approved.)

Three orderlies should be provided at each telegraph office for the delivery of received messages at the station, and runners for the conveyance of messages to a distance. (To be police at most places.)

It is impossible on a narrow road to build the line while troops or baggage trains are passing.

Each telegraph office should be furnished with a good map. (Shall be done.)

The officer in charge should be informed as early as possible of intended movements of Head-quarters, to enable him to provide for the extension of the line. (Shall be done.)

At each important station, where an office will be established from time to time, a small hut or some recognised place should be reserved, and the instrument remain fixed whether in use or not.

If the circuit is not fully occupied with service messages, will the privilege of using it be given to newspaper correspondents or others for private messages? (No.)

H. JEKYLL, Lieut., R.E.

By order, signed G. R. Greaves, Colonel, Chief of the Staff. 19. 12. 73.

B.

LIST OF MATERIALS TAKEN OUT ON BOARD H.M.S. HIMALAYA.

1520 S.S. porcelain insulators.
100 porcelain shackles.
150 G. I. bolts, 4½ inches.
200 G. I. straps, 7½ inches.
900 G. I. pole brackets.
8½ lb. G. I. nails.
400 G. I. nails, 3 inches.
20 lb. staples, No. 4.
20 lb. ditto, No. 8.
2 tons 16 cwt. 3 qr. No. 11 G. I. wire (84 coils).
2 qr. No. 16 do. do.
1 cwt. 1 qr. $\frac{3}{16}$ strand.
300 yards prepared No. 7 G. P. wire.
24 lb. solder.
50 lb. I. R. tubing.
2 direct writers.
2 detector galvanometers.
2 Leclanché batteries, 10 cell.
8 lb salammoniac.
4 axes.
9 augurs.
4 bill-hooks.
9 chisels, wood.
3 ,, cold.
3 crowbars.
8 draw vices and keys.
3 fire pots.
2 files, flat.
3 files, ½-round.
1 file, round.
12 gimlets.
6 hammers, small.
1 set lineman's tools, complete, in case.
6 mallets.
6 picks.
3 pairs pliers, large.
8 hand saws.
5 spanners.
6 soldering irons, large.
2 spades.
10 shovels.
3 tool baskets.
250 porcelain cones.
5 gall. oil, Colza.
4 books, signal message.
1 bottle, tin, oil.
2 bugles, fog horn.
2 cans, tin, oil, feeding, ½-pint.
2 cases, leather.
2 flags, signalling, black.
2 do., do., white.
2 poles, signalling.
2 wheels, cypher.
50 yards cotton wick.
2 pairs scissors.
2 telescopes with case.
4 signalling lamps.
17 lanterns, bull's eye.
10 cans, tin, oil.
6 tinder boxes.

C.

Nominal Roll.

Sergt. Longstaffe, Constructor and Clerk
" Dowie, Constructor
Corpl. Brown, Clerk
" Kenney, Clerk and Constructor
2nd Corpl. Richards, Clerk
Lance-Corpl. Inward, "
Sapper Marlow, "
" Graham, Clerk and Constructor
2nd Corpl. Galpin, Constructor
Sapper E. Allen "
" R. Allen "
" Campbell "
" Ferrier "
Sapper Goddard, Constructor
" Horgan "
" Mock "
" Mossman "
" J. Taylor "
" Wales "
" Williams "
" Fasham "
" Brooks "
" Howard "
" Chapman "
" Bennett "

D.

Instructions for Military Clerks, Gold Coast Telegraph.

The telegraph will be open for work at all hours of the day and night.

The Clerk will sleep in the office, and orderlies will be provided (generally police) to watch the instrument all night, and wake the clerk if it calls.

Army signal message books will be furnished to all offices and to Commanding Officers and Heads of Departments. These forms are invariably to be used.

For the use of head-quarters staff, forms have been provided, marked at the top, "Special message, to take precedence." Any such message handed in is to have priority.

Ordinary messages are to be despatched in the order in which they are handed in.

No private messages, or messages from persons unconnected with the army, will be transmitted by telegraph.

The Clerk is responsible that copies of all messages received are kept, and the originals of transmitted messages.

Each day's transmitted messages will be rolled up, and the date marked outside.

Copies of received messages will be made on the counterfoil of the message book.

Each day's slip will be rolled up, and the date marked outside.

The old messages and slips must be carefully guarded in a safe dry place.

The office diary must be kept up according to the instructions contained therein.

The Clerk will be held responsible for the good order of his instrument, batteries, and office. He is required to keep his instrument clean, to refresh the batteries when necessary, and to pay particular attention to the leads, connections, and earth. All these points must be carefully attended to daily, and by so doing the chance of faults occurring in the offices will be greatly reduced.

With regard to faults, clerks must bear in mind that this line of telegraph presents no facilities for testing and localization. In the event of an interruption taking place, each clerk must therefore thoroughly test his batteries, instrument, and leads before taking any further steps. If he is satisfied that the fault is without doubt on the line, he will next endeavour by putting on earth alternately on each side, to ascertain on which side of him the fault lies. Nothing more can then be done by him, and he will advise the nearest lineman by runner.

Every man employed on the telegraph is expected to use the utmost vigilance to keep the line in good working order. Occasions are likely to arise when he will have to act on his own responsibility, and it is confidently expected that he will on such occasions act with discretion, and use the experience which he possesses.

H. JEKYLL, Lieut., R.E.,
In charge of Telegraphs.

E.

_____ _____ 1874.

Telegraphic Communication is now established between the following places.

_____
_____
_____
_____

Former Notices are hereby cancelled.

H. JEKYLL, Lieut., R.E.

INSTRUCTIONS TO ACCOMPANY OFFICE DIARY.

This diary will be kept by the clerk on duty.
He will enter in it the following particulars each day:—

1. The state of signals at the time of opening.
2. Results of tests of the line and batteries, giving the time at which the tests were taken.
3. Record of interruptions and delays, stating the cause when known, the time and duration.
4. Observations of thunderstorms and earth currents, and their effect upon the instruments or line.
5. Dates of change or refreshing of batteries, and change or repair of instruments, mentioning the numbers of batteries and instruments.
6. Number of messages sent and received in the course of the day.

7. Any unusual occurrence in the office, or any circumstances affecting the working of the circuit.
8. The state of signals at the time of closing.
9. Stations with which communication is established.

H. JEKYLL, Lieutenant.

28. 12. 73. Cape Coast Castle.

N.B.—Nos. 1 and 8 became inoperative when it was ordered that the offices should remain constantly open.

F.

Cape Coast Castle.

Deputy Controller,

Required for to-morrow the undermentioned transport :—

200 men with telegraph stores for Mansue.

I must urge the extreme importance of providing transport for telegraph stores without delay.

The working parties are almost at a standstill for want of the supplies which are lying here.

Unless the works are to be stopped, which would bring down the severest displeasure of the Commander in-Chief, it is absolutely indispensable that transport should be provided.

If no more than 30 men could be produced, and they were sent up to Yancoomassie to morrow, the works could be just continued. Otherwise I must report a stoppage of the telegraph through failure of transport.

Although 100 men were demanded for this day, none appeared, and in spite of repeated efforts, I have been unable to despatch a single load to the front.

I shall be much obliged if you will let me know how many men I can count upon for to morrow.

H. JEKYLL, Lieutenant,
For Commanding Royal Engineer.
3. 1. 74.

Commissary O'Connor.

This will depend upon the number of carriers required to be found for the 42nd Regiment to-morrow morning.

After the 42nd have left, as many men as possible will be placed at the service of the Royal Engineer Department.

I am bound to consider the despatch of the troops as of the first importance, and for this purpose I assented to Colonel Colley's request to maintain in reserve all the men available to day.

R. C. HEALY, Assistant Comptroller.

3. 1. 74. To be returned.

Commanding Royal Engineer.

Since writing the above, I have received intelligence which will prevent my giving you a man until the departure of the 23rd Regiment.

R. C. Healy, Assistant Comptroller.

4. 1. 74.

Remarks upon Lieut. Jekyll's Report by the C.R.E.

Attention has been already drawn to the inconvenience that arose from not taking a telegraph out with the Expedition, and also to the causes that induced me to postpone a demand for telegraph stores until after the arrival of the Expedition in Africa.

I had not beside me a list of telegraph equipment in my demand for stores. I stated generally the nature of the line and the requirements of the service, and I asked to have the list of stores prepared by some officer in the Inspector General of Fortifications' Office.

I considered that having stated the requirements of the Engineer branch in the field, it then became the province of the Inspector General of Fortifications—having at his disposal a knowledge of the most recent improvements—to supply those requirements.

The result showed I was right, the Inspector General of Fortifications having actually anticipated my demand.

The delay in the telegraph arose undoubtedly from the delay produced by the shipment of the telegraph stores in the Dromedary, which caused the construction of the telegraph to clash with the transport of provisions to the front. I handed over 600 men to the transport department at Prahsue; these men employed on the telegraph would speedily have brought up the stores to the front. But it is for the General of an Army alone to apportion the transport (synonymous with labour) to the different branches of the service. Food and ammunition are necessities telegraphs are luxuries of war. Full powers were given to Lieut. Jekyll and Major Jones to obtain labour as they best could; to employ women, children, and any person they could get. The prisoners from Elmina gaol were even added to the telegraph labourers.

Looking to the general bearing of the campaign, the telegraph was eminently successful, and conferred great benefits on the Expedition, upwards of 3,000 messages having passed over the line. It would have done a vast deal more had the stores reached the country a fortnight sooner. That so much was done was due to the untiring zeal, energy, and exertions of Lieut. Jekyll, Sergeants Langstaffe and Dowie, and, after Lieut. Jekyll was invalided, to the exertions of Major Jones, R.E.

Further, it should be stated that the first portion of the telegraph could not have been made but for the material furnished by the Post Office authorities. This shows the great advantage of having the telegraph in Government hands.

Notes on Lieut. Jekyll's Report.

A.—The wire did its duty well, but I consider it was too heavy; it was, however, very useful for many purposes, such as lashings for bridges, stockades, huts, &c.

It is very desirable that experiments should be made with the compound steel and copper wire. I consider that the largest portion of the telegraphs of an army in the field must be overhead wires, and it is a matter of great importance to determine the lightest description of wire that possesses sufficient conductivity and strength.

B.—I think that these drums might have been made lighter; the lightest and strongest description of drum I know is that sold in india-rubber shops for winding garden-hose on. In considering these articles it should be remembered that they are invariably expended, and if they last six months, it is the outside of what will be required.

C.—I am decidedly of opinion that a recording instrument alone is suitable for military purposes. I believe the question of replacing the necessary instruments by sounders is under consideration. If sounders had been in use on the Gold Coast, some of the manipulators would have been useless from the fact of their being deaf, from the effects of quinine.

D.—I concur generally with Lieut. Jekyll's remarks on the insulators. I am disposed to think that a good many of the failures arose from *too hasty and imperfect manufacture*. I base my opinion on the following fact: having heard complaints of these insulators, I narrowly inspected the line from Accrofoomue, the most advanced post to Cape Coast Castle,* as I came down country, and I saw but one damaged insulator. This fact, in my opinion, speaks most highly, not only for the linemen, but for those insulators that did not break. I consider that the best kind of insulator for the field has not yet been arrived at. That termed by Lieut. Jekyll the Post Office pattern fulfilled two requirements admirably. It could be used either as a bracket or on a bamboo, as pointed out by Lieut. Jekyll. I consider the earthenware cap too large. I submit that some practical experiments be made to determine the proper form of wire and insulator for the field. To determine this, a line composed of several descriptions of wire and various insulators should be used; such a line should be of some length, and might take the form of a line from London to Portsmouth, viâ Aldershot, to be used as a War Office line. I feel sure that much valuable information would be acquired by this means; stations being kept at Aldershot and Portsmouth only, would prevent any great cost being incurred. Ebonite of good quality and in large quantities is difficult to obtain. I am disposed to question the advisability of its use, particularly for tropical countries. From what I have seen I should feel disposed to adhere to some description of porcelain.

E.—This should most certainly have been done, and I am the more surprised at its not having been done, because all the stores sent direct to me from Chatham were so arranged. I wish to place on record an opinion that in this, as in

* 106 miles.

so many other cases, stores to be used by the Royal Engineers in the field should be packed and shipped under the inspection of some officer of Engineers who is in communication with the Commanding Royal Engineer, and who understands clearly the nature of the operations. Building stores, such as cement, lime, or sand, are so shipped, and it would be hard to show why a different course should be pursued as regards Engineer warlike stores, the latter being of far more importance than the former.

F.—This is questionable, some offices have much to do, others far less.

G.—Intimation was sent to me of these insulators being on board the Thames.

I received it when I was at the Adansi Hills, and I immediately sent it back to Lieutenant Jekyll, who must have left the country just then. The number of officers that were invalided, and the press of work in the front, prevented my keeping an office open at Cape Coast Castle.

I wish to place on record a strong opinion as to the necessity of there being always an officer of Royal Engineers at the base of operations. At Sebastopol this was found to be requisite, although the base was only a few miles off, and it becomes all the more important in expeditions like the Gold Coast, where a rapid advance of 150 miles is made.

H.—In my demand I asked for 8 clerks; 6 only were sent. Had I known the country when I made the demand, as well as I subsequently did, I should have asked for 16 clerks and 30 linemen.

The Medical Officer at Mansue informed me, as I returned down the country, that the clerk at that station had on several occasions to be taken out of hospital, given a strong dose of brandy, and put to the instrument. These men suffered much, and worked, despite illness and fatigue, with a will and a determination that was far beyond all praise.

I.—I concur most fully with Lieutenant Jekyll in these remarks, and I even go further than he does. I consider that special lines of telegraph should be worked under the War Office, as experimental lines, where revenue for the Post Office should be a secondary consideration. I consider that rapid sending of messages is not of great importance in a military telegraph, but I consider it of importance that every lineman should know how to receive and send a message. There was not one man in the three regiments on the Gold Coast who could send a message. The advantage to the public of having a body of officers and men, trained as telegraphists, ready at a moment's warning for service in the field, was shown on this occasion, and the experiment of keeping trained men usefully employed, costing nothing to the State, ready for the requirements of war, was thus a complete success.

K.—The want of a good strong watch or clock for each office was much felt, more especially as all private watches were useless from the climate. These watches should never again be left out of an equipment.

L.—I concur with Lieutenant Jekyll. Carbon books are now extensively used, and with great advantage in shops and private establishments, and they save time in taking copies.

M.—A special message form, printed in red, or on red paper, should be

adopted for head-quarter messages; these books should be furnished to the head-quarter staff only. An office diary is absolutely requisite.

N.—I believe these results will compare favourably with permanent lines, and, in my opinion, are most creditable.

O.—Of the eight faults, six were caused by trees falling across the line. The last is the only one which appears to bear on the question of the insulators; and I cannot but think some peculiar cause, such as a hastily or badly made lot, here in use, caused the failure. I believe that a light copper wire might, to a great extent, be used without any insulator. Such a line, with a turn or two round the poles, would, I fancy, except in very wet weather, give good results; and even in wet weather I think it might be worked with powerful batteries. The question seems to be, as between additional battery power, or insulators.

R. Home, Lieutenant-Colonel
Late Major, Commanding Royal Engineer,
Gold Coast Expedition.

APPENDIX II.

List of Engineer Tools taken out to the West Coast of Africa.

Augers, 1½ in., shell, handled	6	
„ ½ in., „ „	6	
„ ¼ in., „ „	6	
Axes, felling, American pattern, hickory helves	150	
Helves, spare, American pattern	25	
Axes, pick, 6½ lbs.	30	
Helves, spare	10	
Spades	10	
Shovels	50	
Hooks, bill	150	
Tomahawks, New Zealand, or good hand hatchets	50	
Stones, grind, field pattern, small	3	
Gabion knives	20	
Rope, 1½ in., coils	4	
„ 1 in., „	4	
Stones, whet	6	
Tools, sets, carpenters'	2	
Saws, pit	2	
„ cross cut	4	
„ hand	20	
Bags, sand, tanned	100	
Hammers, claw, 20 ozs.	60	
Handles, spare	10	
Hammers, sledge, 10 lbs.	10	
„ handles, spare	5	
Nails, spike, 5 in. A	600	lbs.
„ „ 8 in. A	800	„
„ „ 10 in. B	200	„
„ clasp, strong, D 2½ in.	200	„
Locks, pad, iron, large, with keys	8	
Forge pack-saddle equipment, new pattern, without pack-saddle	1	
Miners' tools, pack-saddle equipment, without pack-saddle, in boxes, set	1	
Smith's tools set, pack-saddle	1	
Guncotton	100	lbs.
Mining primers with Bickford's fuze attached, complete	25	
Horns, fog	25	
Pontoons, Blanshard's, infantry pattern, with superstructure, complete, for two rafts	4	
Ditto, india rubber, ditto*	4	
Ditto, Fowke's, ditto	6	
Iron, 2 in. by ½ in., flat	150	lbs.
„ 1½ in. by ½ in., „	250	„
„ square 1 in.	200	„
„ round 1 in.	150	„
Deals, 3 in.	700	„
Filters, to weigh not more than 40 lbs. each, in tin or metal cases, of the pattern used in Abyssinia	6	
Pumps, common jack, with hose	10	
Coil, 2 in. rope	2	
Snatch blocks for 2 in. rope	2	
Luff Tackles	2	
Hand blocks	6	
Girders, from Chatham	12	
Two coils, 3 in. rope. Snatch block and tackle for ditto.		

* Not supplied.

APPENDIX III.

Cape Coast. 18 Huts, marked No. 1 Hut to No. 18 Hut. Detail of packing for one Hut.

4	Bundles of	3	each.	Sills and Plates. Sides of Hut.
2	,,	4	,, ...	,, ,, Ends ,,
3	,,	8	,, ...	Stancheons. Sides and Ends.
1	,,	12	,, ...	,, Gable Ends of Hut.
1	,,	4	,, ...	Angle Posts.
2	,,	4	,, ...	Door ,, (2). Head (1). Sill (1).
1	,,	4	,, ...	Struts. Sides of Hut.
4	,,	4	,, ...	Rafters. Intermediate.
1	,,	4	,, ...	,, Ends of Hut.
1	,,	4	,, ...	Angle Ties.
1	,,	2	,, ...	Ridge.
2	,,	4	,, ...	Stumps.
1	,,	8	,, ...	Braces. Sides and Ends.
2	,,	3	,, ...	Surplus Timber.
1	,,	10	,, ...	,, Boards (5) of each sort.
8	,,	15	,, ...	Roof boarding (not cut to a net length).
6	,,	11	,, ...	Weatherboarding. Sides of Hut.
4	,,	11	,, ...	,, Ends ,,
2	,,	12	,, ...	,, ,, ,,

4 Doors.

1 Box of Nails, Screws, Padlocks, &c.

3 Rolls of Felt, each of 3 lengths 19′ 8″ (one length surplus).

55 Total for One Hut.

Two Boxes of Tools, containing—*

10 Claw Hammers.	1 Dozen of Files.
5 Screw Drivers.	5 Firmer Chisels, ¾ in.
5 Axes.	5 ,, ,, 1 in.
5 Hand-saws.	5 ,, ,, 1½ in.
5 Mallets.	20 Gimblets.

APPENDIX IV.

General Order No. 1. 27th Sept., 1873.

Major General Sir Garnet Wolseley, C.B., K.C.M.G., accompanied by the undermentioned officers composing his Staff, having arrived at Sierra Leone, assumes command of the troops in Her Majesty's possessions on the West Coast of Africa, from this date inclusive.

* These tools were of the greatest use; the huts could not have been put together without them.—R. H.

PERSONAL STAFF.

Captain H. McCalmont, 7th Hussars,
Lieut. Hon. C. A. Charteris, Coldstream Guards, } A.D.C.s.
Captain H. Brackenbury, R.A., Assistant Military Secretary.

GENERAL STAFF.

Colonel McNeill, V.C., C.M.G., Colonel on the Staff.
Major J. D. Baker, 18th Royal Irish, A.A.G. and Q.M.G.
Captain G. Huyshe, Rifle Brigade, D.A.A.G.
Captain R. H. Buller, 60th Rifles, D.A.Q.M.G.
Major R. Home, R.E., Commanding Royal Engineer.
Captain A. Rait, R.A., Commanding Royal Artillery.
Deputy Controller M. Irvine, C.M.G., Senior Officer.

APPENDIX V.

Sir, War Office, 5th September, 1873.

I am directed by the Secretary of State for War to acquaint you that it is in contemplation to attach to the Expeditionary Force proceeding to Cape Coast,

Native Carpenters	..	..	..	Thirty
Labourers	..	..	..	Twenty
Smiths	..	..	..	Ten

to be obtained from Sierra Leone.

I am to request that you will call upon the Colonial Engineer at Sierra Leone to engage, if practicable, the foregoing number of men, for general duty with the Expedition to be employed under Major Home, Royal Engineers, at as moderate rate as possible.

I am to observe that the men engaged should be good men of their trade, and that they should be ready to embark for Cape Coast in the steamer which will leave England on the 12th instant, with Sir Garnet Wolseley on board.

In engaging the men, it should be explained to them that the rate of pay for which they may be willing to go, will be subject to the approval of Sir Garnet Wolseley, and that on the return of the Expedition they will be given a free passage back to Sierra Leone.

I am to request that the Colonial Engineer at Sierra Leone (Mr. Jenkins), and the Acting Engineer at Cape Coast (Mr. Mercer), may be instructed to afford Major Home, R.E., any assistance which he may require from them, in the way of obtaining labour or materials.

I am to observe that Major Home, R.E., has been appointed Commanding Engineer with the Expedition, and that the ordinary and current duties of the Royal Engineer Department will continue to be conducted as heretofore.

To the Officer Commanding, I have, &c.
&c., &c., &c. H. K. STORKS.
Sierra Leone.

APPENDIX VI.

Chief of the Staff,

I am desirous that his Excellency the Major-General Commanding should be informed that, after an examination of the country, within a radius of six miles from this place, I am strongly of opinion that no railway sent from England, except that on Mr. Fell's principle, will be suitable. This country was represented as flat. So far as I have explored it, it is covered with mamelons, and intersected with deep ravines, and I regret to say that there are several hills within four miles of this place, on the Dunquah road, that are not practicable for the traction engine in their present state, and much labour will be requisite to make them so. I submit, that if his Excellency desires to work the traction engines on the Mansue Road, that I should examine the road, and set men to work at once to cut down the hills.

6. 10. 73. R. HOME, Major, C.R.E.

APPENDIX VII.

Chief of the Staff,

The question of putting up a telegraph between Cape Coast and some point on the line of march between this and Coomassie is one of some importance, and one on which a better opinion can now be given than I was competent to form in England.

Should his Excellency approve of a telegraph being erected, I submit that the following estimate of men and means be at once forwarded to England:—

	Miles.
Bare wire, for overhead purposes, galvanised, light field pattern	200
Insulated	3
Morse's recording instruments	7
Sounders	2
Galvanometers	9

With a full set of apparatus for working six stations (batteries to be of Matthison's Field Pattern), and 13,000 insulators of the light field pattern. These stores to be packed and accompanied by 25 non-commissioned officers and sappers, of whom eight should be operators, and the remainder trained linemen.

In the supposition that bamboos can be obtained of sufficient size to make poles, and that black labour is available, this line may be carried out at the rate of five miles daily.

It would be advisable that a correct detailed list of stores should be prepared in the office of the Inspector General of Fortifications, and forwarded to Cape Coast Castle. R. HOME, Major, C.R.E.

7. 10. 73.

Immediate.

C.R.E. 9. 10. 73.

Covering letter is written to enclose demand for stores for telegraph. Please draw up and sign demand for stores, to be forwarded in original.

Your first memo. herewith. Please return it.

H. BRACKENBURY, Capt., A.M.S.

A.M.S.

I cannot give a complete list of stores, as I have no Telegraph Handbook with me. But the memo. I herewith furnish is quite sufficient to enable the officer charged with the duty to make a correct list in England. I have written to the Inspector General of Fortifications on the subject, so that the list will be ready when the order passes from the War Office to the I.G.F.

R. HOME, Major.

APPENDIX VIII.

New Fort, Mansue,
20th October, 1873.

Sir,

I have the honour to report, for his Excellency's information, that the fort I began on the 18th, will be completed this evening; it is now fairly defensible.

It contains a central redoubt, cut out of a large ant-hill, which, when roofed in, will form an excellent magazine for a very large quantity of ammunition.

The fort will contain large Commissariat Stores, which I will begin to-morrow. It commands the Dunquah Prah Road, and will hold a garrison of 200 men. From its peculiar shape it may be held, however, by 60 or 70.

I have opened a portion of the Denkera Road, so that the numerous women and children, and hangers on of this camp, may return towards Accra in an easterly direction if pressed. The fort I should be prepared to hold with the 60 rifles.

I hope his Excellency has approved of my remaining here, and trust, if he has done so, he will permit me to call this fort, the first built, Fort Wolseley.

The weather has been very bad; a heavy tornado yesterday, which has prevented my getting burned the large quantity of cut bush, grass, and plantains. The result is miasma; but this is really a healthy place, and when the cut undergrowth can be burned, will, I am sure, be in a good sanitary state.

The moment the fort is finished, I will resume operations on the road. But I should be glad to return to Cape Coast for a few days to see after some matters there, and have, meantime, requested Lieutenant Bell, R.E., to report here on Wednesday next.

The A.A.G. I have, &c.

R. HOME, Major, C.R.E.

APPENDIX IX.

New Fort, Mansue,
8 p.m., 20th Oct., 1873.

Sir,

I have the honour to acknowledge the receipt of your letter (duplicate), dated 16th October, the former copy of which was delivered to me on the 18th instant.

As pointed out to you in my letter dated the 18th, I did not comply with the

Major General's orders, as doing so would have left the volunteers and police exposed at this point.

I despatched Lieut. Gordon as directed, and myself remained here, believing it to be the better course under the circumstances, as your letter was two days old, and my position had been moved from Wonkorsue to Mansue, your letter being addressed Dunquah.

The receipt of your duplicate letter this evening has caused me considerable uneasiness, as it places me in the position of being unable to obey it. No orders have even now been given for the disposal of the very large camp and quantity of stores which can with difficulty be moved.

Under these circumstances, I shall despatch to-morrow morning the non-combatants on the Denkera Road. I shall move the combatants within the fort, and shall await the result.

I may point out to you that I could not have withdrawn the police and volunteers from this place without authority, and that your letter above referred to, far from conveying such an order, referred to them as remaining at the fort.

I have stowage for about 80 gallons of water, and hope to maintain myself for 48 hours against all attack.

In any case, I trust that my conduct may meet with the approval of his Excellency, and I am most anxious to learn that it has done so.

I have, &c.,

The A. A. G. R. HOME, Major, C.R.E.

APPENDIX X.

Memo for the Assistant Adjutant General.

Acrowful, 27th October, 1874.

The following observations and remarks may be useful to the Major General Commanding.

1st. *Mansue.*—This is a high table land, on the top of a hill sloping in all directions, about 500 feet above the sea at Cape Coast Castle.

The road from Cape Coast Castle to the Prah crosses the plateau in a diagonal direction.

There are no huts or walls of any kind standing; the whole place when reached on the 17th October was covered with plaintains and Guinea grass. This has been cleared, and a small stockaded and fraised fort commanding the road has been built. One storehouse, 30 ft. by 18 ft., inside the fort has been finished, and another 40 ft. by 14 ft., begun. The ground has been laid out, sites selected for the hospital, staff quarters, and European lines; the staff quarters are in progress.

The water supply is good; there are three streams, one about 300 yards, one about 400 yards, and another about 600 yards off.

2nd. So far as defence goes, the fort denies the use of the road to the enemy for about 350 yards, but he can easily turn it by moving through the bush.

3rd. *Dunquah.*—The redoubt constructed here gives good cover, and is quite

strong enough to resist an attack; it has a wire entanglement on the salients most exposed to the enemy.

4th. The water supply at Dunquah might be made very good, as there is a very nice little stream issuing from the ground; if opened up and kept clean, this water would be very good.

5th. *Abracrampa.*—This large village is well situated for defence, and has been made into a strong fort; the garrison, at present natives and Houssas, is stronger than is absolutely necessary for defence.

6th. The road from Cape Coast to Mansue is practicable for all arms of the Service, but the passage of cavalry and artillery would soon cut it up. There are many streams unbridged, and many wet spots and swampy pieces which must be put to rights prior to the advance of the European troops.

7th. As far as I could make out from the various scouts I employed at Mansue, it appears that the first alarm at Abracrampa was caused by a body of some 300 Ashantees, who attempted to get into the Prah Road through Abracrampa. Finding it occupied, they fell off, and moved along a bye road, which came out near Dunquah, behind what is termed the "Haunted Road."

This party was followed by a party of 800 men, who were also thrown off by finding Abracrampa occupied. The united force then moved opposite Dunquah, intending to get on the main road there; checked by the force there, they sent scouts to see the Croom at Yancoomassie; these scouts being seen there, gave rise to the report that the Ashantees had debouched at Yancoomassie.

The Ashantees learned, for the first time, on the 25th, that Mansue was occupied, and they are now attempting to fall off from the main Prah Road; a portion, probably the 1,100 already referred to, are working along a path which comes out at Adah Warrah, a croom two miles north of Mansue, the remainder along the Jonquah Faysso Road.

8th. The places that appear to me, and which I beg to recommend as, good camping grounds for the Europeans, are Inquabim, near Yamoranza, Acrowful, at the small village near the water, Yancoomassie, and Mansue.

I submit that the native levies be encamped at Dunquah, and a large croom two miles south of Mansue, which offers every facility for the purpose.

9th. I beg to draw attention especially to the question of water supply. I do not anticipate that wells will help much; I should much prefer using barrels sunk in the streams, with charcoal in the barrels, and pumping out from these barrels.

In the various forts there is more danger, in case of attack, from want of water than from any other cause. At Fort Cambridge, a most excellent tank, containing 300 gallons, was made by digging a hole in the ground, lining it with a large waterproof sheet, and covering it over with plaintain leaves. Tarpaulins used for this purpose would give a good supply of water, and I believe this system and carriers will be the best to adopt for supplying the wants of Europeans.

10th. The exceedingly great difficulty in dealing with transport ind ices me to recommend the formation of a very large number of depôts, and tha nothing

but ammunition should accompany the troops on the march from station to station, the supply of the various depôts being made when the roads were clear.

With reference to defensive works, I submit that the best system to adopt is—

1st. A shelter trench.

2nd. To increase the defensive power, by adding a stockade of bamboo, strengthened by wattlings of split bamboo tied with withes, which are in this country very strong. A shelter trench thus stockaded, protects the heads of the defenders, and prevents them running away before the actual attack takes place, a matter of no little importance.

3rd. A fraised line should be added, and a small ditch excavated. By this system, shelter is obtained at a very rapid rate, and the shelter is improved by each successive operation, and a number of men using different sorts of tools can be employed on the work at one time. The bamboo, which exists all over the country, is admirably suited for these purposes, and placing the natives below the ground when they are to fire, tends to reduce the evil of their firing in the air.

Clearing the bush round defensive posts is, of all means of defence, perhaps the best, as it enables the superior weapon of the defender to come into play.

I have, &c.,

27. 10. 73. R. HOME, Major, C.R.E.

APPENDIX XI.

General Order, No. 16.

Head-quarters, Cape Coast Castle,
17th October, 1873.

2. All intrenching tools now in store, or about to arrive from England, will be handed over to the charge of the C.R.E. Demands for the same will accordingly be made to the officer in charge of the Engineer Park, Cape Coast Castle.

3. On a military post being established, the officer commanding will take immediate steps to strengthen the same against attack, care being taken to clear the bush to the extent of a radius of 60 yards at the least. Previous to marching, the officer commanding the detachment will make application to the officer in charge of the Engineer Park for tools, the number issued depending on the work to be executed.

* * * * * * *

By Command,
T. D. BAKER, Major, A. A. General.

APPENDIX XII.

Memorandum.

Chief of the Staff,

It becomes my duty to call the attention of his Excellency the Major General Commanding to the very small amount of labour at my disposal, and the impossibility I find in increasing it.

I have Artificers at Cape Coast	120
Labourers on the road	220
,, at Mansue	150
,, at Abracrampa	30
Total	520

The amount of work to be done is very heavy, and I should be glad to get this number increased by at least 1,200 men.

The labour is required for—

Clearing sites of camps,
Building huts,
Making roads.

I may further add that the time for this work is only six weeks, and however large a number I may get at the latter part, I cannot, from difficulty of superintendence, make so much of it as of a continually steady force.

31. 10. 73. R. HOME, Major, C.R.E.

APPENDIX XIII.

Sir, Accrofoomue, 22nd November, 1873.

Referring to the railway, now, I presume, *en route* from England, I request that you will be good enough to convey his Excellency's instructions to Captain Buckle, R.E., at Cape Coast Castle, as to its being landed or not.

So far as this expedition is concerned, I do not think the railway will be of any use whatever.

But as it has been sent out, it may fairly be questioned whether, in the event of this colony being retained, it could not be most usefully employed between Cape Coast and Elmina. The ground is most admirably adapted for a railway, and it could be easily made. Whether its construction is required by the traffic, either present or prospective, I do not know, but it appears to me that the question is well worthy of discussion.

The Chief of the Staff, &c., &c. I have, &c., R. HOME, Major, C.R.E.

APPENDIX XIV.

Carriers required for Royal Engineers.

Assistant Adjutant General.

I propose forming an Engineer Battalion at the Prah. This battalion will consist of—

Field Officer	1	Non-commissioned Officers and Men, Naval and Royal Engineers, say	45
Captain	1		
Surgeon	1		
Adjutant	1		
Subalterns	3		
Total	7		

Coloured Foremen	3
Labourers	540
Carriers of Engineer Reserve Stores which must not be in front	40
	583

Or, 7 Officers, 45 Europeans, 583 Natives.

The battalion to be told off as follows:—

Right Wing.—1 Subaltern, 12 Europeans, 1 Foreman, 132 Labourers, 12 Carriers of Mats.*

Left Wing.—The same strength.

Centre.—1 Captain, 15 Europeans, 165 Labourers, 15 Mat Carriers.

Reserve.—The Adjutant, 6 Europeans, 66 Labourers, 6 Mat Carriers.

Carriers of Reserve Stores, 40; or, at the front at work, 45 Europeans, 495 Labourers, with the baggage, 85 Carriers.

TO MOVE THE BATTALION.

	Carriers.
Officers' baggage—7 officers	7
46 men - 1 for every 3	16
7 officers—cooking pots	3
5 tents d'abris	2
Office	1
Hammocks	24
Orderly to Medical Officer	2
Headmen	3
Spare	5
Men's kettles	1
Total	64

21.12.73. R. HOME, Major, C.R.E.

APPENDIX XV.

General Order, No. 7.

Head-quarters, Camp, Prahsue, 9th January, 1874.

1. It is notified for general information that the Military Telegraph Line is now open between Cape Coast and Mansue.

There will be two forms of messages, viz.:—

1st. For special messages for the use of the head-quarters only, which will take precedence of all others.

2nd. For ordinary messages, viz., those from officers commanding and the heads of departments at the several posts, which will be transmitted in the order in which they are handed in.

The message forms can be had on application to Lieut. Jekyll, R.E., Mansue, the officer in charge of the telegraph line.

* This is essential, as the labourers cannot carry their own mats and work too.

The general instructions regarding the transmission of messages have been approved by the Major General Commanding, and posted up in each office.

Two orderlies will be detailed by the Officer Commanding at Cape Coast for the telegraph office at that station, and one orderly for the same purpose will be given by the Officer Commanding at each post along the road where an office is open.

2. As damage appears to have been done to the bridges constructed on the road between Cape Coast and Prahsue by horses, mules, and oxen being taken over them, it is directed that, for the future, these animals will in all cases (with the exception of the bridge over the Okee river north of Mansue) go through the water or swamp alongside of such bridge, and not over it.

3. Captain Jones, R.E., will take Engineer charge of the line of communication from Cape Coast to the Prah, including bridge over that river; his head-quarters will be at Mansue, to which place all requisitions or reports as to damage done to the encampments, bridges, or roads will be addressed.

* * * * * * * *

By Command,
T. D. Baker, Major, A.A.G.

APPENDIX XVI.

Head-quarters, Camp, Yancoomassie Fanti,
Lieut. Jekyll, 28th December, 1873.

The telegraph line must be kept open day and night at Cape Coast, and the clerk must therefore sleep in the room. A light must be obtained from the Control Department, and the clock in the hall of Government House can be removed to the telegraph room.

Be so good as to have a copy of the instructions, which were approved by the Major General Commanding, sent to Acrowful, and each station as it is established, and return me the original.

The Major General is much disappointed at the delay which is taking place in the extension of the line, and he desires me to say that if there is no prospect of its being completed to the Prah by the 20th of January, it will be for his consideration whether it will not be well at once to stop work.

He wishes to know whether it will not be possible to commence immediately to work back from the different stations on the line in, at all events, erecting the poles, so as to be ready for the wire when it does arrive. Please report on this at once for the Major General's information.

By order,
G. R. Greaves, Colonel,
Chief of the Staff.

Chief of the Staff.

There is one point in your memo. relative to the telegraph, that I omitted to refer to, viz., the beginning the work at several points at once. This was my

intention, and as the Major General, I daresay, has seen, bamboos for this purpose have been provided in several places.

Unfortunately, when the Himalaya was off Cape Coast, I was up the country, and a portion only of the telegraph detachment was landed, I believe with the view of keeping them in health until the arrival of the stores from England. Had I had the opportunity, I should have begged his Excellency to have landed the whole force of Engineers, and by nursing them, I might have saved several men who have been expended.

Lieut. Jekyll has my orders to leave Cape Coast the moment Captain Jones arrives, and to take up the superintendence of the line personally. If transport is forthcoming, five miles of line may be done daily, and I feel sure that Lieut. Jekyll will carry out the work; but his Excellency will see that he can hardly supervise men at Acrowful and Dunquah, and live in Cape Coast Castle.

30. 12. 73. R. HOME, Major, C.R.E.

C.R.E.

The C.R.E. at Cape Coast was asked to name the men he wished to have landed, and all those required were landed.

By order,

Head-quarters, Prahsue, G. R. GREAVES, Colonel,
3. 1. 74. Chief of the Staff.

Lieutenant Jekyll.

I have read the enclosed from the Chief of the Staff. I need not urge you to further exertions, because I know that my doing so is not required. But I am desirous that you should obtain what labour and transport is requisite. You will, therefore, hire labour where you can; you will, if requisite, hire women at villages like Acrowful, to carry loads, and you will consider yourself unfettered as regards the expenditure of money in pushing on this line.

In thus giving you full and complete power, I trust you will use discretion in the matter.

30. 12. 73. R. HOME, Major, C.R.E.

C.R.E.

I note your instructions, and have already taken steps to procure additional labour and transport, and will continue to do so until a sufficient quantity has been obtained.

The Dromedary came in this morning. I came here (Mansue) to-day to examine the road, so as to get an idea of what descriptions of stores it is most necessary to get up at once. I return to Dunquah to-morrow, spending the day with the working party, and to Cape Coast next day, to start the stores up. As soon as I see sufficient quantities of stores and tools fairly under weigh, I propose to devote myself to the working parties, and remain with them until the line is completed to the Prah.

Yesterday morning communication with Cape Coast was opened from Dunquah, and numerous messages have passed both ways to-day. I am surprised at being able to work this distance with the very low battery power at our disposal. To-night the line will be up to Yancoomassie. From that station to Mansue there will be much hard axe work. To meet this I shall send up a large supply of tools, and take on a quantity of native labour.

There would be no use in following the suggestion of the Major General of dividing the party with the object of setting poles. We have not got enough tools to equip two parties, but as soon as more tools have been sent up, I shall separate the men, employing a much larger number of natives. If I can succeed in getting all the labour and transport I want, I expect to be at the Prah in a fortnight. Latterly, the cause of delay has been chiefly the want of proper attachments for trees, and the amount of cutting required to give a free passage to the wire.

In a letter which I wrote to the Chief of the Staff yesterday, in answer to a memorandum from him, I endeavoured to point out, without entering into technical details, the reason why the line was not further advanced. This letter will doubtless come before you; I had no time before post to make a copy for your perusal. I am fully satisfied that, with the available materials and men, the progress made has been satisfactory.

Had the Dromedary arrived a fortnight ago, the advance would have been far more rapid, and it should be borne in mind that, up to the present time, the appliances may be said to have been makeshifts.

When I calculated upon a rate of progress of five miles a day, it was upon the following hypothesis:—

No. of Men.		Tools.	Materials.	Transport.
R.E	Native.			
19	100	Plentiful.	Suitable.	Sufficient.

Instead of which the following has been the case:—

No. of Men.		Tools.	Materials.	Transport.
R.E.	Native.			
10	40	Scanty.	Makeshift.	Uncertain or Insufficient.

I need not assure you that no pains shall be spared on my part to push forward the work.

Mansue, 31. 12. 73, 9 p.m. H. JEKYLL, Lieut. R.E.

Chief of the Staff.

Please read Lieut. Jekyll's remarks. Lieut. Jekyll is an officer of very considerable experience in telegraph working, perhaps more so than most civilians in England, having been in charge of one of the large postal telegraph districts

His men are selected, and have been working under him for some years. His Excellency may feel assured if the telegraph is not successful, its want of success will be due to circumstances beyond my control. Knowing the importance of the telegraph, I have endeavoured to push it as much as possible.

R. HOME, Major,
1. 1. 74. Commanding Royal Engineer.

C.R.E.

The Major General is satisfied that every exertion will be made, and he hopes that the line may be completed to this place by the 14th instant.

By order,
G. R. GREAVES, Colonel,
Prahsue, 3. 1. 74. Chief of the Staff.

APPENDIX XVII.

Camp, Prahsue, 29th December, 1873.

The Inspector General of Fortifications.

Sir, Extreme press of work and two attacks of fever have prevented my reporting to you on the nature and progress of the engineer work being carried out under my orders.

As the work has been of a peculiarly heavy character, and continued under many disadvantages, and, as I regret to say, many of the officers and non-commissioned officers have suffered severely, I am anxious to direct your attention to what has been accomplished.

1. On landing at Cape Coast Castle on the 2nd of October, I found the road to Coomassie had been cut to Dunquah through the bush for twenty miles, but was not stubbed or made. My first duty was to erect the huts brought from England; these huts were 18 ft. by 14 ft. I put them up 36 ft. by 14 ft., and made several additional huts out of the gables so saved. The Control Department had their 38 huts built in ten days for their stores. The Deputy Controller, Mr. Irvine, has repeatedly, both privately and officially, acknowledged his obligations to the Royal Engineer Department for the rapidity with which these huts were erected, and the impossibility of his having stores saved except by the use of these huts. To show the difficulties of getting work done, I may add that the first of these huts was put together with my own hands.

2. The road from Cape Coast Castle to Dunquah has been entirely re-made; from Dunquah to the Prah the road has been cut through the bush and made; and no less than 237 bridges of various sorts have been made, some over streams 60 ft. wide and 13 ft. deep. With the exception of the road from Sutah to Faysoo (7 miles), the road is excellent and 12 ft. wide, and although the gradients are from the nature of the country somewhat steep, a carriage could drive the whole way, except the 7 miles above referred to.

This section of the road is through very deep swamps of retentive clay, and although three rows of fascines have been laid down, it is bad, and I fear my

power to do more to it is, from want of labour, now at an end. I have 200 men at it now, laying a fourth layer of 9 in. fascines on it. The labour of making these 72 miles of road has been enormous, huge teak and mahogany trees have had to be hacked in two, a dense bush cleared, and the roots removed, with workmen utterly ignorant of the use of any tool but a knife, and who continually damaged their fingers and toes with the tools entrusted to them.

3. Encampments for 400 Europeans have been made at the following places:—

Inquabim.
Acrowful.
Yancoomassie (Fantee).
Mansue (800 men).
Sutah.
Yancoomassie (Assim).
Barraco.

Each of these encampments consists of 8 huts, 60ft. by 17ft., 5 feet high to the eaves, wattled at the sides, thatched with palm leaves, and all with guard beds, raised 2ft. from the ground. Pumps have been fixed, washing apparatus, kitchens, latrines, officers' huts for 18 officers, Control store, hospital for 12 men, surgeon, &c. At Mansue the accommodation is doubled, hospital for 72 patients, and 4 large Control stores. At Prahsue accommodation for 2,000 men, on the same scale, is now one-half completed. A hospital for 100 patients is begun; a permanent bridge over the river, here from 6 to 10ft. deep, and 60 yards wide, with a current 3 miles an hour, is in progress, covered by a *tête-du-pont* on the north bank.

When mentioning these camping grounds, it should be remembered that a dense bush, perfectly impassable, has had to be cut down, all the stuff removed, and as much as would burn, consumed; the very heavy rains, and the sappy nature of the bush, making the progress of burning difficult.

4. Forts at Dunquah and Mansue have been constructed, stockaded, and fraised, with magazines, and platforms for guns, and the villages of Abracampa, Assayboo, and Acrowful intrenched.

5. These works, undertaken partly under a burning sun, partly in heavy tropical rain, have produced much sickness amongst the Europeans, and even the native labourers have deserted in large numbers, rather than face the difficulties.

Lieutenant Mann, R.E., has suffered from fever and dysentery so much, that I doubt his being able to cross the Prah.

Lance-Serjeant Masters is dead. Lance-Sergeants Rockhead, Hatherley, and Pack, have been invalided. Serjeant-Major Dunne will, I fear, be invalided. Lance-Serjeants Dixon and Barthorpe are slowly recovering. Sapper Webb is dangerously ill from dysentery. Lance-Serjeant Annett has just come out of hospital. I have had three attacks of fever, the last of which kept me for a week in bed. Of the detachment of five men of the 28th Company under Lieutenant Skinner, R.E., recently landed (the Company itself will not be landed until the European force comes ashore), Lieutenant Skinner and three

rank and file have fever at the present moment. Indeed, the latter portion of the work could not have been accomplished had not Commodore Hewett, V.C., commanding the squadron, most kindly placed the services of twelve naval carpenters at my disposal, who have all worked admirably, although I regret to say three have been attacked by fever. I have also had the services for six weeks of Lieutenant Hearle, R.M. Light Infantry, and for three weeks of Lieutenant Hare, 22nd Regiment, as Assistant Engineer.

6. My difficulties have been much increased by being compelled to walk long distances or be carried at a foot pace in a chair. The want of horses has thus pressed more heavily, perhaps, on the officers of the Royal Engineers, compelled to overlook and personally instruct large gangs of idle, ignorant savages, whose language they did not understand, spread over 5 or 6 miles of road, or at distances of 11 or 12 miles when employed on the camps.

7. The difficulties of transport felt by all departments, and the necessity of bringing up food and ammunition to the front, have caused great difficulty in getting Engineer appliances carried, and many articles of paramount importance have been lost or stolen.

8. A further difficulty has arisen from the inability of the Control Department to pay the labourers. I and my officers have thus had to run large sums, £500 to £1,000 in bulk, and distribute to the men as best we can in the evenings, by candle light, after days of excessive fatigue.*

9. The telegraph, under Lieut. Jekyll, is now advanced as far as Acrowful, but can go no further as the stores are embarked in the Dromedary, which I am informed is not likely to arrive for three weeks.

10. When the Europeans are landed the 28th Company comes to the front, and I propose to form an Engineer battalion, by adding twelve natives to each European. This battalion will be formed in three divisions, with a reserve, and each division will cut one of the parallel roads, which it is the Major General's intention to make at 50 yards interval, on the advance beyond the Prah. The work of the Europeans will thus be superintendence only; consequently the tools brought out by the Company have not been unpacked, and are now at Cape Coast in store.

11. I should be failing in a most important duty were I not to bring under your notice the conduct of the small detachment I have the honour to command —conduct which has elicited praises from all who have seen them. On a recent occasion the Major General stated to me that he was not only pleased, but he was utterly astonished at what had been done, and that, had he not seen it, he could not have believed it possible. Under such circumstances to select individuals is perhaps invidious, but I beg to bring to your notice the exertions of Captain Buckle, I regret to say, suffering from varicose veins and ulcers on his legs; Lieut. Bell, my adjutant; Acting Sergeant Major Dunne, Sergeants Page, Loxton, and Annett, all of whom have had charge of encampments, with gangs of 200 men under them.

* In the Peninsula an Assistant Commissary-General was attached to the C.R.E. for this purpose, and a D.A.C.G. to each Divisional C.R.E.

12. I may further add that many of the roads were made close to ($1\frac{1}{2}$ miles from) the main Ashantee force, under a slender guard of native troops, and that the little Engineer camp had to be entrenched nightly, and on very many occasions both officers and men had to sleep on their posts.

13. The small number of Engineer Officers has entailed much labour and consequent sickness on those in the country. I do not now ask for further officers, as seven weeks must elapse before they possibly could arrive, and at the end of that period I trust that this campaign may have been brought to a successful conclusion.

14. Whatever may be the result, I can assure you, Sir, as the Head of the Corps, that no efforts have been spared, no hardships shunned, no duty shirked, that could maintain that reputation of which we are so justly proud.

I have, &c.,

R. Home, Major, C.R.E.,

Gold Coast Expedition.

APPENDIX XVIII.

Ordnance Survey Office, Chester,

Sir, 11th May, 1874.

In compliance with the instructions received by me on my arrival at Cape Coast, that I was to be in Engineer charge of the communications and camps south of the Prah, I at once pushed on the completion of the hospital huts at Connor's Hill, prepared a hospital for yellow fever cases, and made arrangements for fitting some thousand hammocks with carrying poles and sun shades, and having inspected the seventy miles of road up to the Prah, I at once organized parties for keeping the roads and numerous bridges in order. The clearing of the bush for this road had been from 15 ft. to 20 ft. wide, but I at once saw it was better not to attempt in the time and with the force available, to keep more than 5 ft. width of road for the whole length in good order. But with this limit, a good hard road was formed even through the swampy districts and up to the Prah, and I am glad that those who marched over it speak of the satisfactory state it was in on the homeward march. But this was not attained without much labour being expended. Cattle and mules caused constant destruction to the bamboo flooring of the bridges, and heavy thunderstorms cut up the roads, and a great deal required to be done in the swamps about Sutah and Yancoomassie Assin.

To meet the expected pressure, hospital accommodation at Prahsue was fitted up with 200 separate and raised bamboo bedsteads, where the sick and wounded could be conveniently attended to on their way to the coast, and an additional hut with raised bedsteads and lean-to-sheds were formed at every camp south to Cape Coast. Owing to Lieutenant Jekyll being sent down with fever to Cape Coast on the 16th January, and being soon afterwards sent to England, the charge and construction of the telegraph devolved on me, and the telegraph line was extended to Prahsue, and on to Accrofoomue, when I recommended the

line being stopped, on account of the smallness of the trained staff sent out from England. The rapid growth of climbing plants, and the falling trees, created such frequent obstacles, that all the construction men were required for the proper maintenance of the line.

In carrying out these duties I had the assistance of most valuable non-commissioned officers of Engineers, and I only hope our exertions have met with your satisfaction.

I am, &c.,

ROBERT O. JONES, Major, R.E.

APPENDIX XIX.

Accrofoomue,

9 p.m., 15. 1. 74.

My dear Greaves,

I perfectly understand the General's wishes :—

1. Essiamen, post for 60 men, and stores.
2. Accrofoomue, post for 60 men, and large store.
3. Moinsey, post for 60 men, and store.

I never thought of a store at Foomasue, Russell must have made a mistake.

I left my park at Foomasue with an officer and two men, while I brought up rations from Prahsue. The rations and park are now here. I send 150 men for rations to-morrow, 16th, to Prahsue, not wishing to tap Essiamen. My park will thus, I calculate, be one day's march in rear, and I do this to be able to give as many men as possible to the all-important provision affair.

This place is nearly finished, will be to-morrow in the middle of the day.

The road is cut to the outposts $3\frac{1}{2}$ miles ahead. If the General has sent orders to Russell to move on, I shall encamp half-way between Moinsey and Ahquansraimue (the present outposts), on the Parakomee river, and cut back to Ahquansraimue, and forward to Moinsey ; this half-way encampment I must use for the sake of the road. Essiamen is not yet completed, and I have directed Cotter, my officer there, to feed from Prahsue, and not from Essiamen.

On the return of the 150 men I send to Prahsue to morrow, the 16th, I shall bring up the park and my own 16 day's rations to Moinsey, and I trust to be able to send 200 men back for rations again. By working in this way, I hope to save the transport all trouble about feeding the Royal Engineers, and to aid them considerably.

My men are all well, and so is every one else. You will find ground for two European battalions properly cleared, both at Essiamen and here, and I will do for four battalions at Moinsey if I can.

You may depend that I shall work the rather complicated question of cutting road, constructing posts, bringing up rations, and moving my park on, as well as I can, but please give me as *early* notice as you can of movements or alterations, as, of course, they affect the number of men I have to detail for each purpose.

I am anxious about the bridge. People crowd on military bridges as if they were permanent bridges, and I hope a Staff Officer may be detailed, or Mann, if he is well enough, to see any large body across the Prah.

My men, natives, made one march from Prahsue to this place, and thus had a day's rations to the good.

Yours, &c., R. HOME.

APPENDIX XX.

Extract from the Report of the Principal Medical Officer on Hospital Accommodation required by the Force.

The site for the hospital should be Connor's Hill, and there the hospital huts, ordered by the Colonial Government from England in July last, should be erected; one of the three huts should be fitted and equipped for the reception of sick officers.

From Cape Coast Castle to Prahsue (or to Dansamsue, at stations to be fixed by the Major-General Commanding, but it is presumed at distances averaging about 10 miles, a little more or a little less, as military considerations, and the necessity of securing good camp sites, and good water determine), small hospitals should be established; principally intended as resting places for the sick and wounded on the way from the front to the hospital ship; they will have only the simplest hospital equipment. It has been proposed to erect huts of slit bamboo, or of wattle and daub, and plans for them have been prepared by the Commanding Royal Engineer; in my opinion nothing can be better than the plan and construction proposed by him. Each hut will be 36ft. by 14ft. and 7ft. (to the eaves only); for 10 patients this will give each 420 feet of cubic space and 60 of superficial area. The ventilation will be very free by lateral perflation through the walls (the split bamboo not fitting close); outside mats will be provided to keep out cold Harmattan winds at night. The floors will be raised one foot, either pounded clay or split bamboo; windows (without glass) will be provided in sufficient numbers. In an annexe, cut off altogether from the hut, the closet and simple ablution arrangements are placed.

Standing bedsteads of bamboo, made in the native fashion, can be rapidly erected with little labour; these, covered with the woven rush bed (quite as good as a cork bed in every way), at once provide the most difficult part of hospital equipment. A hospital canteen will furnish nearly everything further required. At each small station there should be provision made for thirty sick, and one hut should also be provided for sick officers. The presence of small-pox as a still virulent epidemic amongst the native population makes it necessary to prepare beforehand at each station a small hut to receive cases of infectious disease amongst soldiers. A steward's store and pack store will also require to be provided.

It will not be possible with the means at our command in the short time that remains, to make any provision for the treatment in hospital of native levies,

still less of coolies. Medical attendance will be provided, but the natives should shelter in the houses they can easily construct for themselves.

At Mansue, which from its position must be an important station, with a considerable garrison, it is proposed to establish a hospital for sixty men, an officers' hospital, and a hut for infectious cases. Such of the sick of the garrison who, presumably, might be well in ten days, should be treated in the station hospital ; those likely to be a longer time ill, or weak from illness, should be sent to the hospital ship.

At Prahsue (or Dansamsue) a good hospital for 100 men, and a corresponding one for officers, should be established. The beds here should be ships' cots, slung from standards fixed in the ground at head and foot.

The object of this is threefold. In the first place no more comfortable bed can be had than a cot: second, the cot could, if necessity arose, be taken to supply the place of those lost in the field ; third, sick men might be conveyed in them, without the worry of changing, from Prahsue to Cape Coast Castle.

Tents (if possible the "Sepoy's Paul") may at some stations wholly or partially replace huts of the kind described, and at some villages houses may of necessity require to be occupied.

Certified, a true extract,

Cape Coast, 22nd Nov., 1873. R. N. BUCKLE,
Captain, R.E.

APPENDIX XXI.

Action of Amoaful, 31st January, 1874. Order of March after leaving Quarman.

Centre Column, Sir A. Alison	Lord Gifford's Scouts. 2 Companies 42nd. 1 Detachment Royal Engineers { Major Home. Lieut. Hare, 22nd Regiment. Lieut. Hearle, R.M.L.I. 4 Companies 42nd, Major Macpherson. Rait's Artillery (two 7-pdrs.), Capt. Rait and Lieut. Saunders.
Left Column, Colonel McLeod, CB.	Detachment Royal Engineers, Captain Buckle. Right Wing, Naval Brigade, Captain Grubbe. Russell's Regiment (part only), Major Russell. 2 Rocket Detachments, Lieut. Palmer.
Right Column, Lieut. Colonel Wood, V.C.	Detachment Royal Engineers, Lieut. Bell. Left Wing Naval Brigade, Commander Luxmore. 2 Rocket Detachments, Lieut. Knox. Wood's Regiment (part only), Captain Furze.
Sir G. Wolseley.....	Head-quarters, and Head-quarters and Detachment, 23rd Fusiliers. 2nd Battalion Rifle Brigade.

In Explanation of Pl. XXXIII.

The positions of the troops of the European Brigade (23rd, 42nd, and Rifle Brigade) in this sketch have been put in from the detailed descriptions of the officers who commanded the various companies of the 42nd (given on board S.S. Sarmatian on the return voyage to England); from personal observation (principally of the positions of the 23rd and portions of 42nd), and after reference to the officers of the Rifle Brigade. They are therefore believed to be accurate.

The positions of the other troops have been inserted from published narratives, and partly only from the accounts of officers engaged.

The features of the ground have been drawn from observation, a sketch of Captain Furze, 42nd (commanding Wood's Regiment in the action), and the descriptions of many other officers; the traverse of the road between Egginassie and Amoaful, and of various paths, &c., having been taken from the survey of Lieut. Hart, 31st Regiment, published in Major Brackenbury's account of the campaign.

The following Nos. of companies refer to figures on the sketch:—

23rd, Head-quarters, and Detachment. Lieut. Col. Hon. S. Mostyn, Commanding.	42nd Highlanders. Major Macpherson, Commanding. Major Scott.	Rifle Brigade, Lieut. Colonel Warren, Commanding, Major Stephens, Major Glynn.
	No. 1 Com., Major Baird	No. 1 Com., Major Nicholl
	„ 2 „ Lieut. Brophy	„ 2 „ Major Sotheby
	„ 3 „ Capt. Kidston	„ 3 „ Capt. Somerset
Captain Hutton.	„ 4 „ Lieut. Berwick	„ 4 „ Capt. Dugdale
	„ 5 „ Capt. Creagh	„ 5 „ Capt. Lascelles
	„ 6 „ Lieut. Coveny	„ 6 „ Capt. Cope
	„ 7 „ Lieut. Aitken	„ 7 „ Lt. Hon. T. Scott
	„ 8 „ Capt. Whitehead	„ 8 „ Capt. Cary.

The action was opened as follows (troops uncoloured):—

The Scouts, under Lord Gifford, entered Egginassie about eight a.m.; the 42nd shortly afterwards. Nos. 2 and 3 Companies, 42nd, and three sections of No. 1 Company, were sent by Sir A. Alison up the main path, and one section of No. 1 Company up the path to the left (*a*), with orders to follow it so long as it could do so without losing connection with the remainder of the company, and then to cut a path for itself, Major Macpherson in command. Enemy opened a heavy fire, increasing towards the left. Nos. 4 and 6 Companies 42nd, now sent up the path (*a*) with same orders as those given to the section No. 1 Company, and Sir A. Alison, with Nos. 5, 7, and 8 Companies, under Major Scott, and Rait's Artillery, moved up main path. On arriving at the point (*c*) Sir A. Alison found Nos. 1, 2, and 3 Companies, 42nd, engaged at the foot of the heights north of the stream; No. 5 was ordered to support, and a message sent

to the Major General for a reinforcement. Major Baird, 42nd, who had gone with a section of No. 1 Company to the extreme left, was about this time wounded. Nos. 6 and 4 Companies and the section No. 1 Company, 42nd, who had gone up path (*a*), now debouched on the main path at (*c*). Finding that they could not follow path (*a*) without losing connection with the rest of the troops, they had followed path (*b*) which, in consequence of the main path taking an unexpected bend to the left, brought them suddenly into the latter at (*c*). They had been fired at on the road, and had driven the enemy from a small camp on the left. Nos. 4 and 7 Companies were now ordered to reinforce, and Major Home, R.E., who was in advance, and Major Macpherson (again) were about this time wounded.

The 23rd and No. 3 Company Rifle Brigade, having been sent by the Major General to support, and the column under Lieut. Colonel Wood to the right and Colonel McLeod to the left, having cut their way into the bush, the positions were, at 10.30 a.m., nearly as follows (troops coloured.)

The 42nd, after a severe action, carrying the ridge of heights north of the swamp, their companies in the order shown. Rait's Artillery in action on the path. 23rd in support. No. 3 Company, Rifle Brigade, leaving Egginassie, also in support. No. 1 Company, Rifle Brigade, in action in the clearing to the east of the path with Lieut. Colonel Wood's column, a few men of No. 3 Company with it. The remainder of the Rifle Brigade, Nos. 2, 4, 5, 6, 7 and 8 Companies, in action around Egginassie, which was attacked by the enemy. Wood's Regiment (Major Furze) in action also around Egginassie.

Lieut. Colonel Wood's column engaged in the clearing east of the path, firing north, east, and south; Lieut. Knox's rockets playing into a hollow to the north filled with the enemy.

Colonel McLeod's column having taken the hill west of Egginassie, are lining the edge of a large clearing, and a portion of it, under Colonel McLeod, endeavouring to cut a path and connect with the centre column under Sir A. Alison.

At about 3 p.m. the action went on principally about Quarman At this time Amoaful had been taken. The enemy had been driven from the hill east of Egginassie by Wood's Regiment and the Rifle Brigade (Sub-Lieut. Sherston, Rifle Brigade, here severely wounded), and the positions were nearly as follows:—

The 42nd.—In occupation of Amoaful, except a company or so left at the clearing south of the village, and one at the swamp. *The 23rd.*—North of the swamp, having been engaged in driving the enemy from the camp, whence they had returned after the advance of the 42nd. *The Rifle Brigade.*—No. 1 Company advanced from the clearing close to the main path. No. 3 at the swamp. Nos. 5, 6, and 8 in the village, occupied in intrenching it, &c. No. 2 escorting a convoy of wounded to Quarman. No 4 and half No. 7 at Quarman, where Captain Dugdale, Rifle Brigade, together with some Royal Engineers, some of Russell's Regiment (Captain Barnett), and some of the 2nd West India Regiment, were partially surrounded and attacked by the enemy. Half No. 7 Company to the north of Quarman to assist in bringing in wounded.

Lieut. Colonel Wood's column advancing north of the clearing towards Amoaful.

Wood's Regiment round Egginassie.

Colonel McLeod's column keeping up the line of communication between Amoaful and the troops in rear.

C. W. ROBINSON, B.M.

APPENDIX XXII.

List of Casualties during the Ashantee Expedition.

KILLED.

Captain R. N. Buckle, R.E.	Ten Natives.

WOUNDED.

Major R. Home, R.E.	Sapper Law, J.
Lieut. Hare, 22nd Regt., Assist. Engineer.	„ Brooks, J.
Sapper Little, W.	„ Boyall, C.
„ Voss, J.	„ Wheeler, G. H.
„ Rowe, H.	„ 32 Natives.

List of Men who received the Medal for Distinguished Conduct.

Sergeant Page	2nd Corporal Brooks
2nd Corporal Little	„ „ Hough

List of Non-commissioned Officers who served in detached positions, Building Camps, &c.

Sergeant Page	Lance Sergt. Rockhead
„ Loxton	Sergt. Langstaffe
Acting Sergt. Major Dunne	„ Dowie
Lance Sergt. Annett	Lance Sergt. Dickson.

List of Officers and Men Died or Invalided.

Lieut. Jekyll, R.E., invalided	Lance Sergt. Pack, invalided
„ Mann, R.E. „	„ „ Hatherley, „
„ Skinner, R.E. „	Sapper Marlow „
Lance Sergt. W. Masters, died*	„ Webb „
„ „ W. Barthorpe „ †	„ Galpin „
Sapper W. Stephens „ ‡	Corporal Brown. „
Lance Sergt. Rockhead, invalided.	

* At St. Helena, on board the Simoom.

† At Cape Coast Castle, on board the Victor Emmanuel. The only man sent back from north of the Prah. Seized with dysentery at Ahkankuassie.

‡ On board the Himalaya, after embarkation for England.

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