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THE HOLDING POWER OF EARTH IN CONNECTION WITH ANCHORAGES FOR MILITARY BRIDGES.

By CAPT. C. E. P. SANKEY, R.E.

ANCHORAGES buried in the earth have to be used in various military bridges, notably suspension, tension, and cantilever bridges. The subject is an important one, but it would almost seem that its importance has been under-estimated, as it is more often than not the case when a bridge of any of these types fails, to find that the failure is due to the dragging of the anchorage; an examination of the figures on which the calculations for such anchorages are based will therefore not be without interest.

The pull that may safely be placed on an anchor beam in the earth depends upon a variety of factors, one of the most important being the holding power of the earth itself. This factor is characterised by not being easily measured directly, owing to the magnitude of the stresses involved, as any but full-size experiments are most unsatisfactory, and by not being readily calculable by any formula in common use.

It is therefore necessary to have recourse to tables of accepted results or their equivalent; the tables one naturally turns to, are the two in *Instruction in Military Engineering*, Part III., para. 34 and 35. The former gives the relative holding power of various soils, and the latter some definite values for one particular nature of earth, taken as the standard for the purposes of the first table. Considering the latter table first, it will be seen that it gives the ultimate resistance in lbs. per square foot, to a pull on a buried anchor beam, the values varying with the mean depth of the anchorage and with the inclination of the pull.

In order to appreciate more distinctly the nature of this table, and to discover the basis on which it is founded, the first step seems to be to plot graphically the values given, with the depths as ordinates and the resistances per square foot as abscissæ. Anyone who has plotted this table will have been struck by two things, its suspicious degree of accuracy, the ultimate resistance to a vertical pull on an anchor whose mean depth is 5′ being given to five significant figures, and also the fact that the chart so obtained takes such a curious form that one is led to doubt even the approximate accuracy of some of the values.

As a next step, it is desirable to compare this table with some other authority, but here, at all events as far as the author is concerned, a difficulty arises. He has not been able to find any other table of a

similar nature, probably due to the fact that such results have an interest almost entirely confined to improvised or military bridges, the anchoring arrangements in permanent structures owing their security to very different considerations.

It is therefore necessary to trace the origin of these tables, to see if anything can there be found to throw light upon these anomalies. These tables appeared, in their identical form, in one of the series of very valuable articles contributed by Lieut. (now Major-General Sir Thomas) Fraser, to the *Professional Papers* of the Corps of Royal Engineers. The paper in question is entitled "Experiments on the Holding Power of Earth, and the Strength of Materials," and formed No. VIII. of Volume XXII.

The present author has no intention of criticising the experiments there recorded, but it is possible to divide any paper of this nature into two portions, the results of the actual experiments, and the deductions made therefrom. It is therefore proposed to accept the results obtained as correct, within the limits of accuracy appertaining to the subject and the apparatus, and to limit the investigation to the laws deduced from them.

Table I., in the *Paper* referred to, gives the results of the experiments; these were 36 in number, and varied as regards soil, inclination of pull, depth, extent, surface, and shape of the anchor. Table II., reproduced in *Instruction in Military Engineering*, Part III., para. 34, gives the relative holding power of different soils, and Table III., reproduced in para. 35, gives definite values for loam.

In Table III., certain values are marked with an asterisk to show that they have been derived from calculation, and are not experimental values; these may obviously be removed for the present purpose, and the table will then appear as follows :—

	Vert.	1/1.	1/2.	1/3.	1/4.
1′	808	933	—	—	—
1′ 6″	—	—	2100	—	—
2′	1925	2700	3880	4032	4370
3′	3024	4400	—	—	—
4′	5470	8000	—	—	12260
5′	14112	22000	—	—	—

Taking the columns in order, these values may be examined to see from which experiments each was derived, and the results of this examination are set forth in tabular form in Appendix A. When it

is remarked that out of the 15 values recorded in this table, 10 are dependent on the result of a single experiment each, the fact that they do not plot in continuous curves is no longer to be wondered at. It is, on the other hand, striking evidence of the skill and care with which these experiments were carried out, that they should plot as well as they do.

The results of the remaining experiments may be analyzed as follows:—9, 10, 11, 12, 13, and 14, were carried out in gravel, 16, and 17, in sand, and 35, and 36, in clay; from these experiments the comparative Table II. is compiled. In experiment 15, the buried anchor was a fascine; it was in gravel, and its results may or may not have been used for Table II. Experiment 34 was the case of an anchor with a considerable width or depth, and from it is deduced the statement in *Instruction in Military Engineering*, Part III., para. 34, as to anchorages with faces several feet deep. Experiment 19 was the case of an anchor 3′ in loam, the inclination being 1/3; the result, 4,494 lbs. per square foot, does not appear to have been used. In experiment 32, the inclination was 1/2·5; the anchor was buried 2′ in loam, and gave 7,837 lbs. per square foot.

It is now proposed to find some formula, if possible rational in form though probably with empirical coefficients, that will combine the factors whose variation may be supposed to affect the result, and by applying the experimental values to this formula, it will be possible to find approximate values for these coefficients. These factors may be classified as follows:—

The inclination of the pull.
The weight of the soil.
The angle of repose of the soil.
The tenacity or cohesion of the soil.
The depth of the anchorage.

There are undoubtedly several other factors that may also influence the result, such as duration or suddenness of the pull, but these can be omitted in a calculation that by the nature of things can never pretend to a high degree of accuracy, and their effect will have to be covered by the factor of safety.

If in the first place it is assumed that the particles of earth have no mutual tenacity at all, the resistance offered by unit area of an anchorage can be expressed, by a similar process of reasoning to that given by Rankine* for vertical and horizontal pressures, in the following formula:—

$$r = w \cdot d \; \frac{\frac{1+\sin\phi}{1-\sin\phi} - \frac{1-\sin\phi}{1+\sin\phi}}{\cos\alpha + \sin\alpha \, \frac{1+\sin\phi}{1-\sin\phi}}$$

* *Applied Mechanics*, 7th edition, 1873, Part II., Chapter II., Section 3.

where r is the ultimate resistance per unit of area, w the weight of the soil per unit of volume, d the mean depth of the anchor, its breadth being small compared to its length, α the angle of inclination of the pull to the horizontal, the ground surface being also considered horizontal, and ϕ the angle of repose of the soil. If an actual example is substituted in this formula, it will be seen that in general the results given by it are far too small, but it has an importance, as it gives a minimum below which the resistance cannot fall, short of alteration in the physical properties of the earth, no matter how much the ground may be broken up by careless digging or frequent use; it might indeed be advisable to adopt such values in the case of an anchorage required to last for some time. The formula is also useful in the case of materials such as shingle, whose cohesion is negligible. As the value given is a minimum one, a factor of safety of unity can be used.

As a rule, however, earth has cohesion, and, as shown by experimental results, to a considerable extent. A rational formula to express the result of this cohesion would be very complicated and, owing to the variability of the conditions, hardly practical. It seems fair, however, to assume that the resistance to rupture will vary with the square of the depth, whether the cohesion is considered as bringing the resistance of the soil within the nature of that of a thick fixed plate, or within that of a cantilever, of which alternatives the latter seems preferable, because the earth has to be cut away on one side to allow of the introduction of the anchor beam. It is natural also to suppose that the resistance will increase as the angle of inclination of the pull decreases, and this is borne out by experiment; it is not easy to give a good reason for any empirical allowance for this purpose, but the function used in the expression given below has the merit of increasing in the required way, and will probably be sufficiently accurate for practical purposes. A measure of the cohesion of the earth can be obtained by the height to which it will stand truly vertical when freshly cut, together with its weight aad its angle of repose, the expression used below being derived from a consideration of the equilibrium of a mass of earth, triangular in section, bounded by horizontal and vertical planes, and the plane of the angle of repose.

The following empirical expression is therefore adopted for the resistance of a soil with cohesion between its particles:—

$$r = \mathrm{K}w \,.\, d^2 h \sin 2\phi \{1 + \mathrm{N}(1 - \sin\alpha)\}$$

where h is the height to which the soil will stand truly vertical when freshly cut, the other symbols having the same meaning as before, and where K and N are coefficients, as yet undetermined. By substituting in this expression the values given by the experimental

results, the following values are obtained, by the method of Least Squares, for the undetermined coefficients :—

$$K = \cdot 49$$

$$N = 2 \cdot 37$$

the units used being the foot and the pound. The expression is at best an approximate one, more especially as the values for h had to be assumed for the soils concerned from a remark made in the paper as to their nature, and the simpler values given in the following expression can be adopted, without any loss of accuracy, for the safe resistance per square foot.

$$r = \frac{1}{S} wd^2h \sin 2\phi \, (1 \cdot 5 - \sin \alpha)$$

where S is the factor of safety adopted. In cases where the ground surface is not horizontal, α can be taken as the angle between the direction of the pull and the ground surface, and d should be measured at right angles to this surface.

To save the labour necessary for working out this expression in any given case, it has been put in the form of a graphical chart (see *Plate*); this is more concise than a tabular statement, because a different table would be required for each kind of soil, and even then considerable arithmetical work would be necessary in the interpolation of values. The chart gives the safe resistance per square foot of an anchor beam, whose length is considerable in proportion to its breadth; when its breadth is also considerable, as in the case of the built-up anchorage shown in *Instruction in Military Engineering*, Part III., *Plate* I., *Fig.* 13, it should be regarded as consisting of several portions, none of which should exceed say 1′ in breadth, and the resistance of these several portions added together. In calculating the length of an anchor beam required in any case, an allowance must be added for those portions of it opposite the cable trenches, as these can offer no resistance to the pull; this allowance has been made in the chart.

The chart also gives the minimum resistance offered by earth in a purely granular state, without tenacity or cohesion; the expression only includes a factor of safety of unity, for the reasons given previously. In cases where the values given by the former portion of the chart are less than this value, this latter can be adopted. It can also be used for shingle and other similar materials.

APPENDIX A.

Inclination.	Depth.	Tabular Value.	No. of Experiment.	Experimental Value.	Remarks.
Vertical	1′	808	3	1166·6	Mean 808·3.
			8	450	
	2′	1925	4	1700	Mean 1925.
			6	2150	Expts. 1, and 2, each giving about 900, ignored.
	3′	3024	5	3024	
	4′	5470	7	5470	
	5′	14112	33	14112	
1/1	1′	933	27	933	
	2′	2700	20	2632	Mean 2736. From expt. 21, 3516, it is deduced that small surfaces (1 sq. ft.) give results $\frac{1}{4\cdot7}$ greater than large surfaces (3 sq. ft.).
			22	2822	
			23	2755	
	3′	4400	28	4400	
	4′	8000	29	9400	Reduced by $\frac{1}{4\cdot7}$ to 8000.
	5′	22000	30	27552	Mean 28056.
			31	28560	Reduced by $\frac{1}{4\cdot7}$ to 22000.
1/2	1′ 6″	2100	18	2350	Reason of difference in tabular value not known.
	2′	3880	25	3882	
1/3	2′	4032	24	4032	
1/4	2′	4370	26	4368	
	4′	12260	—	—	Cannot be traced.

IMPROVISED DRAWBRIDGE.

By MAJOR C. S. WILSON, R.E.

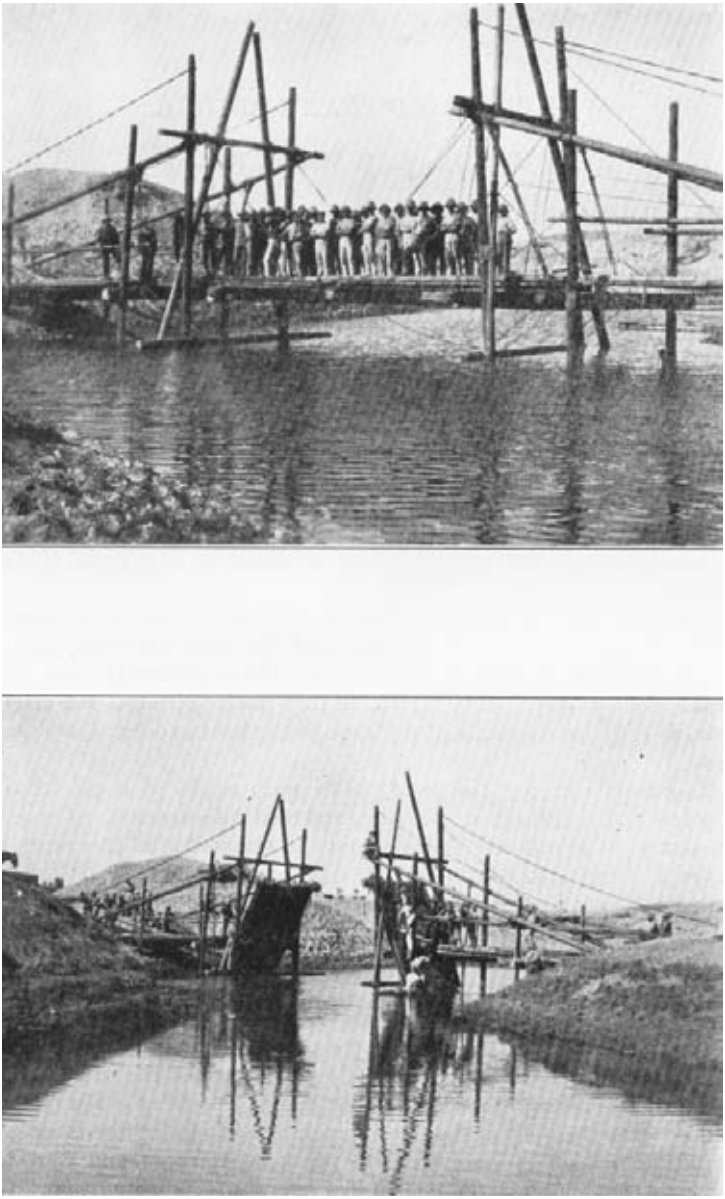
THE following particulars of an improvised drawbridge may be of interest to the Corps in general, as the writer has not seen this principle applied to an improvised bridge before.

As in Egypt there are several canals along which a considerable volume of traffic travels, it was thought we might very possibly, in the event of active operations, be called upon to construct over one of these a bridge which would allow of traffic passing through it. Lieut. J. K. Dawson-Scott was accordingly asked to design such a bridge during the individual training season. Owing to his leaving the command he did not construct it, but his design was gone over and modified by Lieut. A. H. Brown, who afterwards built the bridge during the annual course of the 2nd (Field) Company. The idea was taken from Sir John Ardagh's bridge as shown in *Structural Design*, Part II.

The necessary opening was taken as 30′, which is ample to allow of the native boats (ghyassas) passing, and the total span was 100′, or about the same as most of the canals. These generally have high banks along which the track runs, so that floating bridges are unsuitable, as they necessitate cutting through the banks to get down on to them.

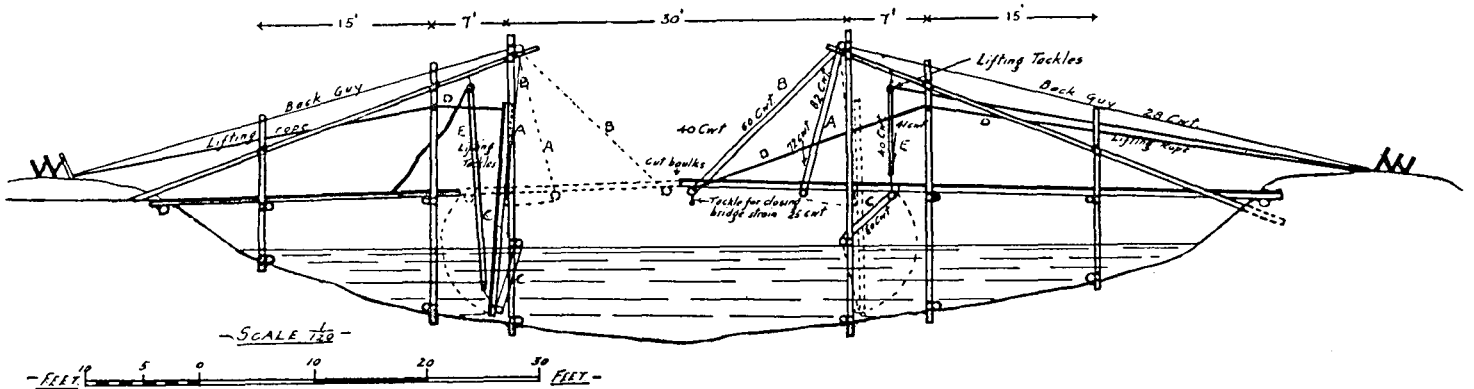
The piers carrying the swing bays were made with 30′ trestles strutted and tied back to the bank, and also side-strutted. The next trestles were 7′ inshore of these, and the remainder at the usual 15′ interval. Each half of the opening consisted of a 19′ bay, bolted and nailed, so that the superstructure would not slip off when the bay was raised. A transom was fixed just inshore of the centre of gravity of the bay, a sling (A) from this to the top of the trestle carrying the weight of the bay when in motion, and also part of the load when the bridge was closed. The front transom had also a sling (B) to the top of the trestle, which only took the weight when the bridge was closed. The pivot was formed by a sling (C) passing round the rear transom and a transom fixed outside the trestle legs, this sling is always taut and governs the path of the bay in opening and closing the bridge.

Lifting ropes (D) were fixed to the front transom, and were led through a snatch block on the end trestle of the standing portion. The best lead was found to be just above the top of the swing bay when the bridge was open, as the pull got heavier as the bay was raised.



IMPROVISED DRAWBRIDGE

DRAWBRIDGE FOR INFANTRY IN FOURS.



Strains calculated graphically for infantry in fours. Slings and guy of $\frac{3}{4}$" steel wire rope.

The lifting can be done by four men on each side. The shore ends of drawbridge fit when the centre is pulled together by the closing tackles and cut baulks are provided for the centre.

Wood chocks are provided to drop between drawbridge and frame to prevent side swaying.

Lifting tackles (E) were fixed to the rear transom for closing the bridge; these tackles also part took of the weight when the bridge was closed. Short cut-baulks were provided in the centre, and the two swing bays finally pulled together by tackles which hooked on to pins in the ends of the front transoms, and took off some of the strain from the pivot sling when the bridge was fully loaded.

The plan and photographs show the bridge clearly. The stresses were worked out graphically and are quite simple.

The swing part was very stiff and steady longitudinally, but when tested by marching over it in fours developed a nasty sharp swing sideways. This was remedied by providing wooden chocks to drop in between the sides of the swing bay and the trestle legs, after which the bridge was quite steady and satisfactory. Four men on each side could work the bridge easily and it only took a few minutes to open and shut. It took rather a long time making, as it was quite new to all of us, and a bad bottom gave trouble with the trestle legs, but I think it could easily be done again by 30 men in 15 hours. The points that require careful watching are the correct length of the slings and the correct placing of the trestles. Altogether it formed a very successful bridge for the purpose in view.

NOTES ON THE PANAMA CANAL.

By Lieut. R. A. Owen, R.E.

Historical.

In 1876, certain Frenchmen directed their attention to the possibility of cutting a canal through the Isthmus of Panama ; the site between Colon and Panama being selected as the best.

In 1878, a concession was obtained from the Columbian Government, and in 1879-80, the Panama Canal Company, with De Lesseps as its President, was floated.

The original plan, to cut a sea-level canal, was soon altered, as it became apparent that a tidal lock was a necessity, since the rise and fall of tide above and below mean sea level is about 9″ on the Atlantic side and about 10′ on the Pacific. Later the damage done by the sudden floods of the Chagres River led to the proposal that a dam should be made for their control ; and finally in 1887, it was decided that a lock type canal was most suitable and economical.

Two years later, in 1889, the Company became bankrupt.

In 1894, the new Panama Company resumed the work and continued until 1904, when the United States Government took over all canal works and properties on the isthmus.

The amount of work done by the French companies is greater than is generally supposed, and it is found that all subsidiary work, such as survey, is excellent, and is of great use to the American engineers who now have the canal in hand. The profile (*Fig.* 1, see *Plates*) shows the amount of excavation done by the French, and the amount done and remaining to be done by the Americans.

Even the present scheme, a lock canal with a dam at Gatun, was originally advanced by the French (in 1879) but was subsequently discarded.

Administration and Organization.

The administration of the whole area of the canal zone, *i.e.* of the strip of land 5 miles wide on each side of the canal taken over by the United States from the Republic of Panama, is under the Isthmian Canal Commission.

The Commission consists of a chairman (Colonel Geo. W. Goethals, Corps of Engineers United States Army), six members, and a secretary. Of the members, three are from the Corps of Engineers, one from the Medical Corps, one civil engineer from the United States Navy, and one civilian, head of the Department of Civil Administration.

The administration is carried out under six departments, as follows: —

(1). Department of Construction and Engineering.
(2). Quartermaster's Department.
(3). Subsistence Department.
(4). Department of Civil Administration.
(5). Department of Law.
(6). Department of Sanitation.

The Department of Construction and Engineering is controlled directly by Colonel Goethals as Chief Engineer of the Commission.

As far as construction and engineering for the canal are concerned the department has three construction divisions—Atlantic, Central and Pacific—each under a division engineer.

In addition, the office of Chief Engineer is subdivided into three divisions. The first division deals with designs, contracts, etc.; the second with maintenance of plant, machines, shops, supervision of expenditure, allotment of work, etc; the third with survey, meteorology, and hydrography.

The Quartermaster's Department deals with *personnel*, labour, quarters, transport, construction of buildings, material and supplies.

The Subsistence Department deals with the subsistence of the Commission employees generally. This department manages all restaurants, hotels, and labourers' messes in the zone, and provides all supplies for both single and married employees.

The Departments of Civil Administration and Law deal with all such matters as obviously come within their scope. Such are:—posts, customs, taxes, police and prisons, schools, courts, legislation, adjustment of claims, etc.

The Department of Sanitation deals with all medical, surgical, sanitary and quarantine services.

In addition to the six departments there is an Examiner of Accounts, a Purchasing Officer (in Washington), and a Disbursing Officer, each with a large staff.

The Secretary of the Commission has charge of all canal records and investigations of complaints, in addition to the Isthmian Canal Commission band of 43 performers.

GENERAL DESCRIPTION.

Starting from the Atlantic there is to be a channel, 500′ wide and 41′ deep, from deep water in Limon Bay to Gatun. This channel runs north to south in direction, the general direction of the canal being N.W. to S.E. From Limon Bay to Gatun is approximately 7 miles.

At Gatun are situated the flight of three twin locks to raise ships from sea level to the canal level 85′ higher. In addition to the locks it has been necessary to construct a dam at this point, 8,000′ in

length, 1,500 to 2,000′ thick at base, and 115′ high. This dam will form an artificial lake, Gatun Lake, through which ships will pass in a channel from 500 to 1,000′ wide. The area of the lake will be approximately 160 square miles. The ship channel has of necessity certain bends in it as the accompanying plan shows (*Fig.* 2, see *Plate*).

The full depth of water in this channel will be 45′ to allow a small margin for dry seasons. After about 23 miles of this lake, Bas Obispo is reached, and here the Culebra Cut begins. The Culebra Cut extends for 9 miles, *i.e.* as far as Pedro Miguel and through it the channel is 300′ wide. The amount of excavation for the cut is shown in the section—the bottom of the cut being at an elevation of 40′ above sea level, and the highest point at the sides 534′, and of the original centre line 312′, above sea level.

At Pedro Miguel, a single twin lock lowers ships 30′ to a small lake whose surface is 55′ above sea level. Through this lake a channel, about 1 mile long and 500′ wide, with 45′ depth, leads to Miraflores. At Miraflores two twin locks will lower ships to sea level on the Pacific side. From Miraflores a channel 500′ wide, 45′ deep and about 8 miles long, leads to deep water in Panama Bay.

It will be seen that the canal, once the exact site was settled, offered the following main problems to the engineers :—

(1). The locks at Gatun, Pedro Miguel and Miraflores.
(2). The Gatun Dam and Lake.
(3). The Culebra Cut.

The channels to deep water at each end and the smaller dam at Miraflores call for no special notice when compared with the more striking features.

Locks.

The design of all locks is similar and it will therefore be sufficient to describe only those at Gatun. These consist of three twin locks of concrete, each 1,000′ in length and 110′ in breadth with a 60′ dividing wall between (*Fig.* 3, see *Plate*). Double gates are provided at the ends, and in each lock a subsidiary gate is placed about two-thirds along its length as a safety device, and to permit of economy of water when passing small vessels. At each end of the flight the dividing wall is continued for about 1,000′ and will be used for ships to tie up to before entering the lock. In each lock the rise and fall of water is 28·3′ and this with a 41′ minimum depth of water gives a minimum height of wall of approximately 70′. The actual height is a few feet more.

Some little difficulty has been found at Gatun in obtaining satisfactory foundations. At one point it was necessary to excavate to 66′ below sea level, whilst the south middle wall is being built on piles for a considerable portion of its length. The remainder of the structure rests on solid rock.

The gates consist of steel frames with steel plates riveted on both sides, and pivot on two hinges only.

The water is to be run to and from each lock through circular channels, of 18′ diameter, in the side and centre walls. Circular holes in the floor of the lock communicate with these channels, and as these holes are very numerous, about 110 in each lock, and regularly spaced over the floor, the filling and emptying should be smoothly effected.

Along the tops of the centre and side walls will be laid rails, on which tractors will run to handle ships through the locks. These tractors and all machinery in connection with the working of the locks will be electrically operated, and the machinery for operating gates and valves will be placed in recesses in the centre wall.

The mode of procedure in handling a ship through the locks will be as follows :—The ship will come up under its own motive power to the extension of the centre wall, and there tie up. It will then be taken in hand by four tractors, two towing in front, and two behind ready to slow the ship as necessary. These tractors will control the ship through all three locks, at a rate of not more than 2 miles an hour, and not until the ship is clear of the last lock will her own motive power again be used. Each tractor will weigh over 30 tons, and its electric motors will operate gears which will engage a rack rail on the track.

Hawsers from the ship will be attached to windlasses on the tractors. These windlasses will be provided with friction clutches to slip at a strain of 25,000 lbs., thus allowing for a certain amount of elasticity in the pull.

SAFETY DEVICES.

The most likely cause of damage to the locks is a ship not under proper control ramming the end gates. To prevent this, extra gates are provided at each end as already stated. In addition, a special chain fender has been designed and will be fitted about 500′ above and 230′ below the upper and lower gates respectively. When not in use, these chains will rest in grooves in the floor and side walls of the locks. When in use they will be raised to the surface of the water forming a barrier to the passage of ships. Such resistance will be provided by hydraulic cylinders at each end of the chain, as will absorb the energy of a ship of 10,000 tons moving at 4 miles an hour before it strikes the lock gate.

In addition floating caisson gates will be provided for use in front of the upper gates in case of emergency. These caissons will also be of use in permitting examination and repairs to gates below them.

For the operation of all valves, gates, etc., an electric plant, to be operated by water power, is to be installed at Gatun, with a reserve plant at Miraflores to be operated by steam. Transmission lines will communicate throughout, and current from either or both can be used for any part of the canal.

Gatun Dam and Lake.

The Gatun Dam, with its lake, is in some respects the most interesting feature of the canal. Certainly the people of Cristobal and Colon, towns below, must feel that here lies the most important work on the isthmus.

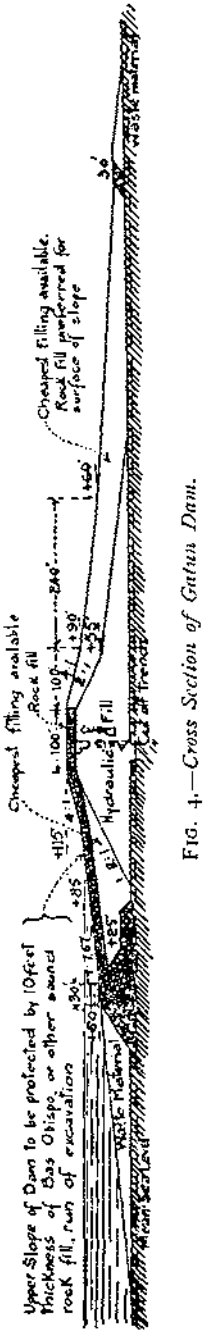


Fig. 4.—*Cross Section of Gatun Dam.*

The section (*Fig.* 4) shows the main dimensions of the dam at its widest point. The central portion consists of a hydraulic fill held in place by a fill of the cheapest material available. The outside of the dam on the south side is protected by a 10′ thickness of sound rock fill. The hydraulic fill is obtained from the bed of the Chagres River and is pumped in a semi-liquid state (80 per cent. water) into the dam by special dredges. The water drains and evaporates away leaving the hydraulic fill in place. At the present time this hydraulic fill is almost completed. The material to form the fill to hold the hydraulic fill in place is brought down by trains mostly from the Culebra Cut. The rock for the protecting wall comes mostly from Bas Obispo.

Elaborate boring operations have been carried out on and near the site of the dam to determine the soundness and impermeability of the underlying strata, and it has been proved that there is no appreciable flow of water below the surface near the site of the dam.

The Spillway is situated nearly in the centre of the dam. Its plan forms a segment of a circle, radius of crest 314·6′, radius of toe 221·6′, distance between abutments 312·9′. It is of ogee section, with a height of 69′ above sea level at the top of the concrete work and 10′ above sea level at the toe. The steel gates controlling the water above 69′ are arranged between 13 concrete piers.

The apron extends about 960′ north of the dam and consists of concrete on rock, the concrete being 4′ thick near the dam and 1′ thick at the toe of the apron. The width of the Spillway Channel is 285′.

Culebra Cut.

The Culebra Cut is 9 miles long across the highest part of the isthmus. Its width at the

bottom is 300′, and lowest depth 40′ above sea level. The section (*Fig.* 5) shows the cut at Culebra which is at its widest point, and illustrates the state of the excavation work on 1st November, 1911.

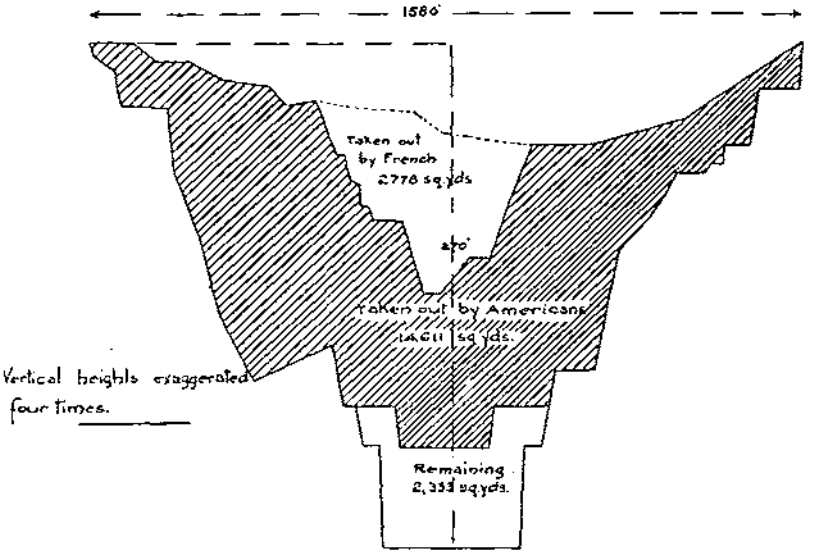


FIG. 5.—*Cross Section of the Culebra Cut at Culebra where the trench is at its greatest width.—1st November, 1911.*

It was here that the French did most of their work, taking out in all some 20,847,000 cubic yards of material between 1881 and 1904.

Since 1904 the Americans have removed about 85,000,000 cubic yards. In each of the years 1909, 1910 and 1911 close upon 20,000,000 cubic yards were removed. This great increase is due in a large measure no doubt to the improved and more plentiful machinery of the Americans. But besides this the nature of the material has changed; the French had to contend with a sticky clay that could not be dropped from the shovels and that would not carry a railway track; the Americans have to deal with a harder material that can be more easily handled.

The organization of the excavation work and handling of material to and from the dumps is most perfect, and no delay is allowed to occur.

The work of excavation in the Culebra Cut is done almost entirely by steam shovels, working after a blasting party. Small charges of dynamite are exploded to loosen the soil or rock sufficiently for the steam shovel to be able to work. A very large quantity of dynamite is used throughout the canal (400,000 lbs. per month) and a certain amount of difficulty has been experienced with it. Such surprises as may be expected to result from free nitroglycerine, quickly liberated by a slight acidity of the underground water, are not unknown.

The chief point that has attracted attention to the Culebra Cut has

been the difficulty experienced with land slides. These slides are of three kinds: firstly, those due to the slope of excavation being left steeper than the material will assume in its natural state. These give but little trouble, as the amount of material to be handled is small and when sufficient has slid and been removed the surface reaches its natural slope and all movement ceases. Secondly, slides occur when layers of clay overlie smooth layers of harder material sloping towards the centre of the canal. These slides are more troublesome than the first as the amount of material is often large and tracks are upturned thereby. So far the only means of combating them has been by excavating all material as it entered the cut. Experience has shown that it is only a question of time before they cease entirely.

Thirdly, breaks have occurred, especially at Culebra itself. These breaks are likely to take place where ever the underlying rock is of poor quality. As the excavation proceeds the distribution of weight is changed, until the breaking point of the weak stratum is reached and the rock is broken up and squeezed out of place, either heaving up the bottom of the cut or pushing out the side slopes.

The method of dealing with these breaks, is to try to relieve the pressure by cutting benches along the walls of the canal. This treatment has proved very successful. It is also to be observed that when the water is let in, support will be given to the weak strata of rock and greater stability may be expected.

The reports current as to the gravity of these slides are greatly exaggerated, and no one of the isthmus appears to have any misgivings as to the entire success of the cut at an early date. The two largest slides of the last year have been at Cucaracha and Culebra, covering 47·1 and 46·6 acres respectively.

Other possible causes of damage to the canal are flood and earthquake.

The former danger is entirely removed by the construction of the Gatun Lake. In the early days much damage was caused by the Chagres River, which is liable to very sudden floods. Now, however, the great volume of water impounded in the Gatun Lake will not be appreciably affected by the largest flood on the Chagres.

As to earthquake; this region is supposed to be very liable to earthquake, but no records exist of any serious damage from this cause and the stranger in Panama is shown the ruins of a church destroyed by fire, amongst which can be seen standing an elongated flat arch of about 40′ span which certainly could not have withstood any serious earth-tremor. As the church is over 200 years old we have proof that the region has suffered no dangerous earthquake for that time.

SANITATION AND SUBSISTENCE.

The main work of the Americans during the first 2½ years of their occupation of the canal zone was the rendering of the whole area healthy by methodical sanitation. In 1904 the total force employed was slightly more than 6,000 with a death rate of 13·3 per thousand. This low death rate was due, not to absence of disease of all sorts, but to the immunity of the population, who had gained this immunity through years of exposure to infection and weeding out.

On increasing the size of the force a large non-immune population was introduced, and, in 1906–7 with a working force of 32,314 the death rate was as high as 39·3 per thousand. From this date, under the improved sanitary conditions, the death rate dropped until in 1910–11, with 49,129 employees, the death rate per thousand was 11·34.

The same drop in the death rate is seen when we consider the total population of the isthmus, Panamans as well as Commission employees. In 1906–7 with an average population of 87,215 the death rate per thousand was 42·08, in 1910–11 with a total population of 154,255 the death rate was 22·10.

It is interesting to note that deaths amongst employees from malaria in 1906–7 numbered 205, and in 1910–11, 41, and this with an increase in total numbers of about 50 per cent. for the latter year.

These results have been obtained by the elaborate sanitary measures in operation throughout the whole area.

Take for instance mosquito destruction :—All surface water is collected in open channels as far as possible, and at the head of each channel is a drip vessel containing crude oil, which drips at a rate sufficient to thoroughly oil its own section of channel. Near any settlements these channels are usually concreted to avoid any chance of hidden unoiled pools forming. All streams are kept clear of weed and their banks of vegetation ; reservoirs are stocked with fish, and bush and high grass cleared in a wide belt around houses. In the dry season the main streams and rivers become almost stagnant in places, and require oiling in addition to the smaller streams and pools. Every house used as a dwelling is thoroughly screened with wire gauze which is periodically inspected and kept in good repair ; many of these houses are old French buildings which, though without roof ventilation, are entirely suitable to the climate. A noticeable point about all buildings on the zone, is that the predominant colours for outside painting of walls and roofs are dark grey and black ; even the roads are dark. These colours look gloomy to the newcomer, but after a time he appreciates the rest they give to his eyes. This is very different from the colours of buildings in many tropical places where the blaze of light and colour at midday is unbearable. An elaborate system of charts is in opera-

tion, by means of which cases of disease are plotted in the head office and the location of any source of infection is immediately shown up.

The purity of the water supply has been carefully preserved. Catchment areas are regularly patrolled and are guarded from trespassers. Periodical analysis of water is carried out and distilled water is delivered by the Commission to its employees. Sewage disposal also is carefully planned and carried out.

The sick are provided for in two main hospitals at Ancon and Colon, with subsidiaries at each settlement. A hospital car goes through the line daily to take patients to the main hospital. A sanitorium for convalescents has been established on Taboga Island, about 9 miles out to sea from Panama. Medical treatment is free to all employees.

A great factor in preserving the health of the negro population has been the establishment of labourers' messes under the Subsistence Department. This system has compelled the negro to spend a portion of his earnings on good food instead of, as he prefers to do, saving money on food to spend it on personal adornment. A well-fed, and therefore healthy, negro without patent leather boots, is found to be more useful as a labourer than one who has half starved himself in order to purchase the latest thing in footwear.

The Subsistence Department operates, in addition to 30 labourers' messes, the Tivoli Hotel at Ancon, 19 line hotels, and three night restaurants, besides providing all supplies for employees who do not make use of the messes or hotels. The total number of persons catered for being upwards of 60,000. The department has a gross revenue of about 1¼,000,000 dollars and a profit of some 60,000 dollars.

Boats arrive from the United States at intervals of five days with supplies sufficient for five days' consumption. These are stored into a large cold storage warehouse at Cristobal (Colon), where a reserve store of about 14 days' supplies is held in case of the non-arrival of any ship. In addition to the cold storage warehouse, there is at Cristobal, under the control of the Subsistence Department, a laundry and bakery which provide for the needs of the whole zone.

Only the most modern machinery is installed, and the most scrupulous cleanliness is observed throughout. One is shown a dough-mixing machine doing the work of 69 bakers, and other elaborate machinery such as collar and shirt pressers, coffee roasters, beef mincers, etc., etc. In dealing with food stuffs great care is taken to avoid all unnecessary handling, and each class of supply is stored by itself. For instance one store is allotted to carcases, another to butter, a third to vegetables, and so on.

Only the highest qualities are purchased, and the contractors are kept up to the mark by careful inspection. For instance every egg,

of which about 40,000 are issued daily, is carefully examined before it leaves the store, and very few complaints as to quality are received.

Those employees who do not make use of the messes are allowed to send in written orders for goods to the Cristobal Office, and each day a train goes through the zone distributing the supplies ordered, and replenishing those at the hotels and messes.

A system of coupons is in use at the messes by which an employee may draw a part of his pay in a meal coupon book; each coupon being good for meals at the particular class of mess which caters for the individual concerned. In the case of "gold" employees the cost of a coupon is 30 cents and is good for one meal. For white labourers who receive 20 cents an hour working pay, the cost of the coupon, good for three meals, is 40 cents; for coloured labourers, who receive 10 cents an hour, the cost of the coupon, good for three meals, is 27 cents. The meals provided are such as are considered suitable for the class of employee using the mess.

DATE OF COMPLETION.

The original estimate of time required for completion fixed the opening date as January 1st, 1915. The work has advanced so rapidly, however, that it has been found that the canal will be ready about 18 months earlier than this. The Gatun locks will be completed, as far as concrete work is concerned, in June, 1912, and the Pedro Miguel and Miraflores locks in the following October. The gates and operating machinery for all locks should be in place by June, 1913, when the locks will be ready for operation. The Gatun Dam will probably be completed early in 1913, and the Culebra Cut in July, 1913, if no serious slides occur beyond those estimated for. By the latter date the exterior channels to deep water will be sufficiently advanced to pass shipping, so that in all probability the canal will be near enough to completion, for operation by July, 1913.

The official opening may take place a month or two later.

In conclusion the writer wishes to express his thanks to Colonel Goethals who kindly placed at his disposal means for collecting the information contained in this article.

HISTORICAL DOCUMENTS OF MAJOR-GENERAL SIR J. T. JONES, BART., K.C.B., R.E.

(*Continued*).

The following notes on the Artillery operations against Olivença, Ciudad Rodrigo and Badajos, were prepared by Sir A. Dickson, K.C.B., R.A. for Sir J. T. Jones when the latter was preparing his history of the Peninsular War.

Operation against Olivença.

1811.—*April 9th.*—Marshal Beresford advanced from the Guadiana and invested Olivença. When the Marshal reconnoitred the place, Major Dickson pointed out an inclosed Lunette in front of the gate of San Francisco, from which he knew by a former visit to Olivença, the curtain could be battered in breach. Immediately after this examination, the Marshal dispatched Major Dickson to Elvas, to bring forward the heavy Ordnance required for the Siege, and he reached Elvas the same night.

10th.—Six heavy Brass 24 Prs., with heavy travelling Carriages, 300 Rounds per Gun, and all other requisite Stores were got ready, as also Block Carriages for Conveying the Guns.

The exertions of Lieut. Sabugal belonging to the Portuguese Arsenal at Elvas, were very distinguished in this preparation. 104 Pair of Bullocks required for moving the equipment.

Major Dickson sent off the following Engineer Stores to Captain Squire, loaded on 24 mules :—6,000 Sand Bags, 130 Shovels, 35 Spades, 60 Picks.

Three Petards prepared to accompany the train of Artillery in Consequence of an order received from the Marshal this day.

11th.—The equipment detained till the latter part of the day waiting for Bullocks.

A Portuguese Company of Artillery, consisting of 100 Officers and men of the 3rd Regt., under the Command of Captain Jose de San Payo, attached to the equipment.

It advanced about a league on the road to Jerumenha this Evening.

12th.—The heavy Artillery proceeded this day to Jerumenha and crossed the river, the Petards by an order received from the Marshal were left at Jerumenha.

13th.—This morning the heavy Artillery arrived at the Camp before Olivença, and immediately proceeded to the Neighbourhood of the point of attack.

The breaching battery for four 24 Prs. being in readiness, an attempt was made this night to put the Guns in battery, but it was found impossible to effect it, from the badness of the road, and the Circuit the Guns were Obliged to take.

14th.—The Communications having been made practicable this Evening, the four Guns were moved into the breaching battery with all the necessary Ammn. and Stores in readiness for opening in the morning. The old magazine of the Lunette answered admirably for the Security of the Ammunition.

Two batteries for the Field pieces of the German Artillery were also established, to keep the fire of the Enemy in check.

Breaching Battery.—4 Brass 24 Pounders.

Supporting Batteries.—3 Field pieces viz.—1 5½ Inch Howr., 2 6 Prs.; 3 field pieces, 6 Pounders.

15th.—The Breaching battery opened its fire against the Curtain to the left of the San Francisco gate at 8 a.m., and the fire was continued without intermission till 11, the distance being about 340 yards; the Enemy at that hour showed a flag of truce, which occasioned a suspension, after which the fire was resumed for a few rounds, and then they surrendered at discretion.

The Portuguese Artillery though mostly Young Soldiers, showed a good spirit in this operation, the fire was well directed, and not a Shot was thrown away, which is best proved by the result, for the breach was nearly practicable in 4 hours by the expenditure of 320 Rounds.

A brisk fire from five or six Guns, and a good deal of Musquetry, was kept up by the Enemy against the breaching battery, and the Portuguese Artillery had two men killed, and six wounded.

The Field pieces of the German Artillery materially assisted in drawing the attention of the Enemy during the attack.

Expenditure of Ammn.—Battering Guns, 80 Rounds each; Field pieces, 60 Rounds each.

Cadet Francisco Joze Franco of the 3rd Regt. of Artillery, was promoted to 2nd Lieut. for good Conduct on this Occasion.

Ordnance Captured.

Ordnance Mounted	Brass	8 Prs. ...	...	...	1
		4 Prs. ...	...	...	2
	Iron	12 Prs. ...	...	...	5
		8 Prs. ...	...	...	2
		6 Prs. ...	...	...	2
Ordnance Dismounted		Brass 8 Prs.	...	...	1
		Iron 12 Prs.	...	...	2
				Total	15

The Iron Guns which the French had found laying on the works without Carriages, were very ingeniously mounted by them on Strong Bullock Cars, by the addition of Frame work, and a block under the pole, which rendered them very manageable, as temporary Gun Carriages.

A.D.

Preparations for the Siege of Ciudad Rodrigo.

1811.—*July 19th.*—This day Lord Wellington assembled the following Officers, at His Head Quarters The Quinta de St. Joaó, near Elvas:—Lieut.-Colonel Framingham, C.R.A.; Lieut.-Colonel Fletcher, C.R.E.; Mr. Kennedy, Commissary Genl.; Major Dickson, Comg. Portuguese Reserve Artillery.

His Lordship informed these Officers that it was his intention to undertake the Siege of Cuidad Rodrigo, that he had ordered Fourteen Sail of transports with an English Battering train on Board round from Lisbon to Oporto, and that he wished Major Dickson to proceed to Oporto by way of Almeida, to take the direction of the Conveyance of the train up the Douro to Lamego, and from thence by land to Trancoso, where the equipment would assemble in the first place.

The train in question was as follows:—

			Rounds per Gun Grape Case, &c., included.
	24 Prs. Iron... ...	34	644
	18 Prs. Do.	4	440
	10 Inch Mortars Do.	8	525
Brass	5½ Inch Do.... ...	10	348
Brass	8 Inch Howrs. ...	2	215
	5½ Inch Howrs. Iron	20	348
	Total	78	

From this equipment Lord Wellington made the following Selection of Ordnance to be employed—

24 Prs. Iron	34
18 Prs. Do.	4
10 Inch Mortars Do.	8
8 Inch Howrs. Brass	2
	—
	43
	—

The Calculation was first made on the 20 iron 5½ Inch Howrs. were 48 pieces, but by a Subsequent Order, added, making 68 pieces in all, and by appropriating the 5½ Inch Mortar ammn. to these Howrs., they were compleated to 520 Rounds each.

An Estimate having been made of the land transport required for 48 pieces of Ordnance, allowing 8 pairs of Bullocks for each, and also for the Conveyance of the necessary Stores, and the proportion of ammn. required for two days firing, at the rate of 175 Rounds a Gun, and 80 Rounds for each Mortar and Howr. per diem, the following was the result:—

	Pairs of draught Bullocks.	Bullock Cars.
For Ordnance, Spare Carriages, Forges, &c.	381	—
For Powder	—	171
For 24-Pr. Shot	—	396
For 18 Pr. Do.	—	35
For 10 Inch and 8 Inch Shells	- -	200
For Laboratory and General Stores, &c. ...	—	90
Total	381	892

In addition to the foregoing there were required 200 Bullock Cars for the Engineer Stores.

There being a deficiency of powder in the equipment, Lord Wellington desired Col. Framingham to order 1,600 Barrels from Lisbon to compleat the train at Oporto, and he also directed that Two Companies of British Artillery should be immediately ordered to Oporto by Sea, there to be placed at the disposal of Major Dickson.

These points having been Settled, Lord Wellington drew up the following memorandum of instructions for the guidance of those Concerned :—

Memorandum.

19*th July*, 1811.

1*st*.—The Heavy Ordnance and Stores, and Engineer Stores now embarked in the Transports in the Douro, being required at Cuidad Rodrigo, measures must be adopted to remove them thither.

2*nd*.—They must be removed into Boats at Oporto and carried by water to Lamego.

3*rd*.—At Lamego they must be landed and the Ordnance removed at Once by 384 pairs of Bullocks to Trancoso. The Stores that is to say 350 Rounds for each 18 Pr. and 24 Pr. Gun, and 160 Rounds for each 10 Inch Mortar, &c., to be removed there on 892 Country Carts.

4*th*.—The Engineer Stores to be removed to Trancoso upon 200 Country Carts.

5*th*.—The 892 Carts mentioned in No. 3 to be unloaded at Trancoso, and to return to Lamego to bring up to Trancoso the remainder of the Stores.

6*th*.—Upon the Arrival of the Second quantity of Stores at Trancoso, the whole Ordnance, and the Stores for 350 Rounds a Gun and for 160 Rounds each Mortar, &c., in 892 Carts, and the Engineers Stores in 200 Carts, to move to Cuidad Rodrigo.

7*th*.—The Ordnance Stores to be unloaded at Cuidad Rodrigo, and the 892 Carts to return to Trancoso for the Second Convoy.

8*th*.—Colonel Framingham to order from Lisbon to Oporto 1,600 Barrels of Powder to Compleat the quantity at that place to what will be Sufficient with the Battering train.

9*th*.—Major Dickson is requested to proceed to Oporto, in order to Superintend the removal of the Ordnance and Stores from thence, and Colonel Fletcher will send there an Officer of the Engineer Department.

10*th*.—These Officers will Communicate with the Gentlemen employed by the Commissary General, to collect the necessary boats and Carts, and the matter should be Arranged in such a manner, as that the Stores could be at Lamego, at the same time the Carts would be ready to remove them.

11*th*.—The two Companies of British Artillery now at Lisbon to be ordered to Oporto by sea.

12th.—Probable time these operations will take :—

12 days for Major Dickson's Journey to Oporto.
6 days for the removal of the Ordnance and Stores to the Boats.
6 days from Oporto to Lamego.—(Pezo de Regoa).
8 Days landing Stores from Boats, and moving up the Hill to Lamego.
4 Days from Lamego to Trancoso.
4 Days Carts to return and load.
4 Days Second trip to Trancoso.
6 Days to Cuidad Rodrigo.
6 Days to return to Trancoso.
6 Days to bring Second quantity of Stores to Cuidad Rodrigo.

Total 62 Days.

(Signed) WELLINGTON.

The Object of Major Dickson visiting Almeida on his way to Oporto, was to examine the Shot and Shells remaining at that place, to see if there was any quantity available for the Service in View, particularly 24 and 18 Pr. Shot, of which there was a deficiency in quantity with the train. A further object for his proceeding by this route was to examine the passages of the Coa at the Bridge of Almeida, and the ford of Porto de Vide on the Northern side of the Serra de Marofa, and afterwards to inspect the roads from thence to Trancoso and Lamego.

Orders were immediately sent off to Lisbon, for Major Bredins and Captain Glubbs Companies of the Royl. Artillery being sent round to Oporto, and directions were transmitted at the same time for 1,600 Barrels of powder being forwarded there.

21 July.—28th.—Major Dickson Commenced his Journey this day, and he reached Almeida on the 28th though detained two days on the road by a Severe intermittent fever.

He found Almeida without any garrison, and every thing in the greatest Confusion in the place, from the double destruction it had undergone, there were 197 pieces of ordnance either spiked and Unserviceable, 155 Gun Carriages and mortar beds, and a quantity of Tumbrels, Limbers, Forges, and other Stores but all in a most dilapidated state.

The quantity of projectiles was very considerable, but much Scattered and mixed. He found however a compleat pile of 3,760 Spanish 16 Pr. shot, which would answer tolerably well for the British 18 Pr., and there being a proportion of 24 Pr. Shot that would answer mixed with the others, the Acting Governor, Lt.-Col. Joaó Nepomuceno Reboxo, undertook to have them Guaged and Seperated, and to Communicate the results; as Major Dickson could not wait such an investigation.

July 29th.—Major Dickson continued his journey by Porto de Vide, Trancoso, and from thence to Lamego, at which place he arrived early on the morning of the 1st August.

Lamego, Augst. 1st.—He immediately proceeded to Mr. Assistant Commissary General Boyes, and having arranged with him respecting the preparation of Transport, he waited on Genl. Bacellar, the Governor of the Province, and after explaining the nature of the duty to be performed, he requested of His Excellency that the roads from Lamego to Almeida, by Cotimos and Pinhel, and also by Trancoso, might be repaired. He further requested that 1,000 Militia might be in readiness to escort and assist the train on its march. General Bacellar promised to take immediate measures to provide for these Objects in an efficient manner.

Major Dickson then wrote to Lord Wellington, that the route by Trancoso was very mountainous and difficult, and that there were a number of passes so steep and rocky, as to require a length of time to make them practicable for heavy Artillery, for which reason he begged to propose the train should proceed by the route of Villa da Ponte, Torrinha, Cotimos, and Pinhel, and that one of the first of these places should be chosen as the station of deposit, instead of Trancoso.

Oporto, Augst. 3rd.—Major Dickson having made these Arrangements he embarked in a light Boat on the Douro at Pezo de Regoa early on the morning of the 2nd August, and arrived at Oporto on the morning of August 3rd, at which place he found the two Companies of Royal Artillery (Bredins and Glubbs) just arrived from Lisbon—the latter under the command of Capt. Power.

Mr. Assistant Commissary General Mackenzie was using every endeavour to procure Boats, but although an embargo was laid on the river to facilitate the Object, he had found great difficulty in Obtaining them from the lowness of the river, and the consequent impossibility for the largest description of boats to navigate when loaded, over the Shallows between Oporto and Vimieiró, and for the small boats to pass the rapids above that place, for which reasons during the Summer season the middle sized boats alone are employed to go the whole way to Pezo de Regoa but these even can only take two thirds of their loading to Vimieiro, and they are attended by small boats with the remainder to compleat their cargo at that place.

Augst. 4th.—This day the two Companies of R. Artillery, assisted by a Detachment of the 4th Regt. of Portuguese Artillery, Commenced the operation of shifting the Battering train and Engineers Stores from the transports into Boats, and the work continued without intermission from day light in the morning till dark at night, except when delayed by want of Boats.

In the mean time all the workmen in the arsenal, with a number of additional ones hired for the purpose, were employed in altering the Carriages for Bullock draught, in making lamboens of which 300 were required, and also about 600 or 700 open Boxes, to be placed on the Bullock Cars for the Conveyance of Shot and Shells—these Various works requiring at least 10 days to compleat.

The Boats as they were loaded were sent off in Divisions as follows :—

	Boats. Large.	Small.
August 7th.—Sailed	21	19
8th.—Do.	19	18
9th.—Do.	26	13
10th.—Do.	12	2
The work now delayed for want of Boats.		
11th.—Sailed	4	3
Still delayed.		
12th	9	15
13th.—Sailed	7	10
14th.—The remainder of the Stores loaded and sent off	7	9
Total	105	89

The whole train therefore was dispatched up the river in 194 Boats, with all the altered Limbers and Carpenters work which had been executed at Oporto.

Lieut. Lindsay was sent off on the 11th to Pezo de Regoa, to make arrangements for receiving and landing the Stores,—and on the 16th August The British Artillery with a Detachment of Portuguese Artillery and Artificers marched for the same destination.

14th.—This day Major Dickson was attacked with a Severe fever, which rendered it impossible for him to continue the duty, he therefore on the 17th August sent off an express to Lord Wellington at His Head quarters Fuente Guinaldo, to inform him of the same, and his Lordship in consequence dispatched Brigade Major May to Lamego to superintend the further movements of the train.

His Lordship in consequence of Major Dicksons Communication of the 1st, approved of the proposition for avoiding Trancoso, and He authorised the train proceeding by any other Route Major Dickson might prefer, at the same time giving him directions to notify to His Lordship the place he fixed on for the first Depot; In consequence of this Major Dickson Selected Villa da Ponte as the point of Assemblage instead of Trancoso. His Lordship also gave orders to have the road repaired which leads across the Coa to Almeida.

September 3rd.—The Passage of the train up the Douro, and its debarkation at Pezo de Regoa, was effected with the Utmost regularity without any Material loss or accident, and by the exertions and Excellent Arrangement of Mr. Deputy Commissary Genl. Boyes in supplying the means of transport, the train was forwarded in divisions to the Rendezvous at Villa da Ponte, after which the Bullock Cars returned to Pezo de Regoa for a second load.

4th.—Major Dickson being recovered from his illness, he left Oporto this day, and reached Lamego on the 5th Sept.; where he

found Brigade Major May preparing to set off for Villa da Ponte, having dispatched the whole of the Ordnance with the exception of the mortars, and the greatest part of the Ammn.

9th.—After arranging with General Bacellar with regard to the Detachments of Portuguese Artillery and Militia for the Service of the train, and having settled with Mr. Boyes every thing for keeping up and supplying the transport, Major Dickson left Lamego on the 8th, and joined the train at Villa da Ponte on the 9th, where he found Major May busy in repairing all damages occasioned by the March.

There is a great deficiency of Wheelers in the train, to put to rights the 24 Pr. Wheels, which have been a good deal shook by the March in consequence of their dryness from having been so long on board of ship, which renders it necessary that they should be drawn together.

It is but justice here to notice, the admirable manner the roads had been repaired under the Superintendance of Senhor Manuel Camello Fortes da Pina Ozorio, Captain Mor and Governor of Linhases, to whom General Bacellar had entrusted this duty: The difficult turnings in Villages, hollow ways, and other objectionable parts, had been avoided by detours, which in many cases were opened through Vineyards and other Cultivated ground.

Sept. 19th.—Previous to this period Major Bredins Company having been removed from the train for Field Service, it was replaced by Capt. Halcombes Company which joined at Villa da Ponte this day. There are also attached to the train about 250 Portuguese Artillery men of the 4th Regiment under the Command of Capt. Miron.

Sept. 22.—Brigade Major May returned to Head quarters.

Sept. 25.—The following was the disposition of the train for movement:—

		Pairs of draft Bullocks.	Bullock Cars for Stores and Ammn.
1st Divn.	Lieut. Bourchier—12 24 Prs. ...	105	336
2nd Do.	Capt. Halcombe—12 24 Prs. ...	105	336
3rd Do.	Capt. Power— 10 24 Prs. / 4 18 Prs. ...	118	363
4th Do.	Lieut. Love— 20 5½ In. Howrs / 2 8 In. Do.	74	232
5th Do.	Capt. Miron— 8 10 In. Mortars	79	323
Spare ...	... ...	69	—
	Total 68	550	1590

	Bullock Cars.
Engineer equipment Lieut. Marshall	320

A much greater number of Bullock Cars were found necessary than originally calculated on, in consequence of the draft Bullocks of Beira and Tsar os Montes being small, and of a Description very

inferior to those of the Alemtijo—the quantity of cars before mentioned actually existed in the first instance, the greatest part of them soon after this period were sent to Lamego to assist in forwarding provisions to the Army, and by desertion and Casualties the numbers dwindled away in such a degree, that the train at no period afterwards had ever more than 400 Carts effective, Exclusive of the Engineer Dept. The draft Bullocks which were of an excellent description were never Seperated from the train.

Novr. 16th.—Major Dickson received an order to move with the train to Almeida.

18th.—Capt. Halcombe's 24 Pr. Division and Lieut. Love's Howr. Division marched. The Engineer Stores marched this day by way of Trancoso.

19th.—Capt. Power's 24 Pr. Divn. Marched.

20th.—Lieut. Bourchier's 24 Pr. Divn. Marched.

21st.—Capt. Miron's Mortar Division Marched.

22nd.—Capt. Halcombe and Lieut. Love reached Almeida with their Divisions, and the others arrived in succession.

This movement was accompanied by little or no Ammn., the Bullock Cars not having rejoined the train, a proportion however were soon afterwards Supplied, which were unremittingly employed all the month of Decr. in bringing forward Ammn. to Almeida, but from the season and the severity of the weather; it was impossible to do more than bring forward Gun Ammn., and the quantity of that even would have been insufficient, had it not been from the number of Eight Thousand 24 Pr. Shot found available for the British Guns, by a Careful Selection from the Accumulation of Shot in the garrison. As no part of the Shells therefore for the Mortars and Howrs. could be brought forward, the efficient train was reduced to 34 24 Prs. and 4 18 Prs.

As soon as the Battering train was Parked in Almeida the whole of the Draft Bullocks were sent back to the neighbourhood of Villa da Ponte for the sake of Forage.

1812.—*Jany. 1st.*—This day Lord Wellington issued the following memorandum, preparatory to the attack of Cuidad Rodrigo, it being determined that Gallegos shall be an intermediate depot to supply the Siege.

FRENEDA, *Jany. 1st*, 1812.

Memorandum for:—
Mr. Bisset.
Col. Fletcher.
Major Dickson.

1st.—The Cars sent by General Alava now employed in collecting at Las Agallas the Fascines, and Gabions, and pickets made by the Light and 3rd Divisions, and all the cars at the Cantonments occupied by the Light Division, and M.-Genl. Colvilles Brigade in the 3rd Division, to Rendezvous at Las Agallas on the 5th to be loaded with Gabions and Fascines and pickets on the same day, and to move on the following morning to Cuidad Rodrigo.

2nd.—Colonel Fletcher will charge the Officer of Engineers at Las Agallas with the management of this concern.

3rd.—The 90 Cars unemployed and in readiness, and the 66 expected to arrive this day are to be sent on the 2nd to Almeida, 50 of them are to be loaded with the Laboratory and Small Stores required by Major Dickson; 106 must be loaded with what is required by Colonel Fletcher and to move on the 3rd to Gallegos.

See Seperate Memorandum.

4th.—All the Cars in the Cantonments occupied by the 3rd Divn. except M.-Genl. Colvilles Brigade, by the 4th Divn. including those sent by Genl. Alava and Genl. Paele's Brigade, by M.-Genl. Stopford's Brigade, and the 40 Carts expected from Don Julian, are to rendezvous at Gallegos on the 5th, on which day they are to be loaded with Fascines and Gabions.

5th.—The 16 Carts at Saelices are to be loaded with Fascines and Gabions at Saelices on the 5th.

6th.—The 50 Carts which will have brought the Laboratory and Small Stores of the Artillery to Gallegos on the 3rd, are to be unloaded the same day and to be loaded at Gallegos with Fascines and Gabions.

See Seperate Memm.

7th.—The Carts mentioned in the 3rd, 4th, 5th and 6th Articles are to move to Cuidad Rodrigo loaded with Engineer Stores on the 6th.

8th.—The Mules (50) in the Engineer Dept. to be sent on the 2nd to Almeida to be loaded with Engineers tools and to proceed on the 3rd to Gallegos, on the 4th to return to Almeida for the remainder of the tools, on the 5th to Gallegos, and on the 6th to Cuidad Rodrigo.

9th.—53 Mules with the 1st, 48 with the 3rd, 57 with the 4th, 68 with the 7th, 102 with the Light Divisions.

To proceed to Almeida on the 3rd, and to be loaded with powder and shot in their proper proportions; and to proceed on the 4th to Gallegos.

10th.—The Gun Bullocks now grazing at and in the neighbourhood of Celevico to go to Almeida as soon as possible to draw the guns from Almeida to Gallegos on the ——— and from Gallegos to Cuidad Rodrigo on the ———.

11th.—In proportion as the mules belonging to the reserve Ammn. of the 5th and 6th Divns. and Cavalry will arrive at Almeida with powder and shot (from Villa da Ponte) they are to be loaded with powder and shot in their due proportions, and sent on the 1st day to Gallegos and on the 2nd to Cuidad Rodrigo.

12th.—The Carts now employed with Major Sturgeon, and the new Carts are to be sent to Almeida, as soon as he will have done with them to be loaded with powder and shot in their due proportions, and to carry these articles to Gallegos, there lay them down, return the following day to Almeida, and the following day bring Fresh loads to Gallegos.

13th.—The Mules mentioned in the 9th and 11th Articles will be employed to carry this powder and shot forward from Gallegos to Cuidad Rodrigo.

14th.—The Carts mentioned in the 1st, 3rd, 4th, 5th, and 6th Articles are to return to Gallegos and Las Agallas on the day after

they will have quitted those places to be reloaded with Fascines and Gabions, &c., are to proceed on the following day to Cuidad Rodrigo.

W.

N.B.—It is desirable that the mules mentioned in the 9th Article should lodge the Ammn. (Small Arm) at the following places on their way to Almeida :—

That of the 1st Division Alameda.
That of the 3rd and 4th Do. Gallegos.
That of the 7th at Sabugal.
That of the Light Division at Guinaldo.

FRENEDA, *Jany. 1st*, 1812.

Seperate Memorandum for :—
Mr. Bisset.
Col. Fletcher.
Major Dickson.

Ninety Cars now at Freneda, and sixty six expected from Brigr. Alava, to be sent on the 2nd to Almeida to be loaded, 106 with Engineer Stores, and 50 with Small and Laboratory Stores of the Artillery, to carry these Articles on the 3rd to Gallegos, return on the 4th to Almeida ; and load with Powder and Shot, return on the 5th to Gallegos, and lay down the powder and shot, and to be reloaded with Engineer Stores to proceed to Cuidad Rodrigo on the 6th.

W.

Jany. 3rd.—The movement of the Stores to Gallegos commenced this day as directed in the foregoing Memoranda, and Continued with as much activity as the Supply of transport would admit.

Memorandum, Jany. 4th, 1812.

1st. Eighty Carts only of those which left Almeida yesterday and are now at Gallegos, to be sent back to Almeida, to be there loaded with Articles for Col. Fletcher, and to proceed to Gallegos the 6th.

2nd. Forty Carts of those now at Gallegos to come to Freneda on the 5th to be loaded with Stores of Col. Fletcher at Freneda, and to go to Gallegos the 6th.

3rd. The 45 Carts which were sent to Almeida this morning, to be loaded with powder and shot, and to go to Gallegos on the 5th and there remain, the powder and shot being laid down at Gallegos.

4th. All the Carts which will go to Gallegos excepting the 80 and 40 ordered away by the 1st and 2nd Articles of the Memorandum, to be detained there and loaded with materials and stores of the Engineers Department.

W.

Instructions to General Officers Commanding Divisions.

Jany. 8th.—The Commander of the Forces proposes to attack Cuidad Rodrigo, and in order that the troops may suffer as little as possible from exposure to the weather, he intends that the operations shall be carried on by each of the Divisions of the Army employed alternately for 24 hours.

B.-General Packs Brigade with the exception of the 4th Caçadores will do duty with the Light Division.

The 4th Caçadores will do duty with the 1st Division.

When a Division is ordered for the duty of the Siege, each of the Battalions belonging to it is to march from its Cantonments before day light in the morning, the troops from the Several Cantonments of the Division Seperately, by the shortest and most Convenient route, which the General Officers Comm̃g. Divisions are requested to ascertain, the Troops will be able to cross at the Fords above La Caridad, and all the fords below the Ford of Carbonero inclusive. The troops are to have with them a Days Provisions Cooked, and they are to be followed by two Days Spirits and no other baggage.

A Sufficient number of men to Cook the Provisions for the Day the Division is relieved, are to be left in the Cantonments.

As soon as the first Battn. of the relieving Division shall move on the ground, the General Officer Commanding the Division which has performed the duty for the preceding 24 hours will commence the relief by sending off to their Cantonments a proportionate number of troops, those of course first, which have the greatest distance to go to their Cantonments, and the relief will proceed in proportion as the troops shall arrive.

The Chief Engineer will require daily from each Division—

20 Miners.

30 Artificers or persons accustomed to work, with a porportion of Non-Commd. Officers.

These men will be fixed upon before the troops march from their Cantonments and are to be placed under his directions, (with a list of their names and the Regts. to which they belong) on the arrival of the troops on the ground.

Each Regiment is to take along with it the Intrenching tools belonging to it.

There will be orders daily respecting the working parties, Covering parties, Guards, &c.

The Musket and Rifle Ammn. attached to the Light Division is to be taken to the ground the first day and remain there.

The 9 Pounder attached to the 4th Divn. will likewise be taken to the ground the first day and remain there. The Artillery men are to be relieved Daily by those belonging to the Brigades and troop attached to the 1st, 4th, and Light Divisions.

The Engineers will order to the ground a Sufficiency of cutting tools to enable those men not immediately on duty to supply themselves with Fire wood. These tools to be handed over from the Relieved to the Relieving Division.

Each Division to be attended by the Medical Staff belonging to it, a place will be fixed upon to which Men who may be wounded are to be carried to be dressed, and means will be provided of removing them from thence to their Cantonments.

(Signed) WM. DELANCEY, *D.Q.M.G.*

Jany. 8th.—Cuidad Rodrigo was invested this day, and the trenches were opened at night, after the Redoubt Renaud on the upper Teson had been carried by assault.

Jany. 11th.—The Gun Bullocks having arrived at Almeida on the afternoon of the 9th, the train marched from thence the following day for Gallegos, and on the 11th continued its march to the ground marked out for the Park near Cuidad Rodrigo, the ordnance being as follows :—

24 Prs. Iron of 9 feet on travelling carriages	... ...	34
18 Prs. Do. of 8 Do. on Do. Do.	... ...	4
	Total ...	38

with a proportion of Spare Carriages, Forges, Gins, &c., &c., to Compleat, and by the Evening of the 11th there was in the Park all the Laboratory and General Stores required for the Service, with two days Ammun. for 38 Guns, a similar quantity being in Depot at Gallegos in readiness to bring forward.

A proportion of Bullock Cars were assigned to bring forward Ammn. from Almeida to Gallegos, and the Small Arm Ammn. Mules were to Convey the Supplies from Gallegos to the Siege, to keep up the proportion for two days firing.

The Corps of Artillery under Major Dickson's orders for the Service of the Siege was as follows :—

British Artillery.

Captain Halcombes Company, N.C.O. and Gunners ...	96
Capt. Glubb's Do. under Capt. Power, Do. Do. ...	75

Portuguese Artillery.

1st Regt. Artillery { From Capt. Cunha's reserve Brigade of 6 Prs.	70
1st Regt. Artillery { From Lieut. Costa's reserve Brigade of 6 Prs.	70
Detachment of 4th Regt. of Artillery, under Captain Miron	230
36 Guns.	
6	
Total ...	541
Deduct two reliefs ...	432
216 at 6 men each.	
2	
For Laboratory and Magazine duties, Escorts, and to replace casualties	109
432 number of men for two reliefs.	

British Officers Names.

Capt. Halcombe.	Lieut. Bourchier.
Capt. Dundas.	Lieut. Love.
Lieut. Goeben, K.G.L.	Brigade Major May.
Lieut. Grimes.	Capt. Dynely.
Capt. Power.	

Portuguese Officers Names.

1st Regt.	4th Regt.
Capt. Joaó de Cunha Preto.	Capt. Joao Victoria Miron.
Lieut. Antonio da Costa e Silva.	Capt. Francisco Januario Mariz.

With a due proportion of Subalterns of both Regiments.

Night between 13th and 14th Jany.—This night Guns were got into the Batteries as follows :—

No. 1.—Two 18 Prs. against Convent St. Francisco.

No. 2 } Two 18 Prs. / Seven 24 Prs. } To breach the body of the Place and Fausse Braie at the Saliant Angle of the Fortress.

No. 3.—Sixteen 24 Prs.

Jany. 14th.—About an hour before sun set the batteries opened, viz.—

2 18 Prs. against St. Francisco.

2 18 Prs. / 23 24 Prs. } To batter in breach distance from 560 to 580 yards.

The chief object of the two Guns against St. Francisco, was to open the garden wall of the Convent, but the swell of the ground in front of the Battery, prevented the Guns from bearing on the Wall, the fire however was continued on the body of the Convent till dark, but without much apparent effect.

By the time the fire of the breaching batteries begun to be Correct and Steady, it was obliged to cease on account of night setting in.

The Enemy kept up a Tremendous fire of Shot and Shells, but without any very material effect.

The Convent of St. Francisco was carried by assault this night.

Jany. 15.—As soon as it was day light this morning, the breaching batteries recommenced their fire with 23 24 Prs. and 2 18 Prs., and continued the same during the whole day without intermission, and by the Evening the Wall of the Fortress was so much shook and injured as to afford great hopes of success.

The Enemy kept up a heavy fire particularly of shells which occasioned a good many Casualties.

Night between 15th and 16th.—Five 24 Prs. were got into No. 1 and 2 this night.

Jany. 16.—Batteries opened in the morning with 28 24 Prs. and 2 18 Prs. against breach but so heavy a Fog came on they were obliged to cease firing at ½ past Nine oclock.

The Expenditure of Ammunition to this period, was 2,790 Rounds of 24 Pr. and 340 Rounds of 18 Pr. Shot.

Jany. 17.—This morning still continued very Foggy but it cleared up at noon. The breaching batteries as soon as it was sufficiently clear to point the Guns, continued their fire without intermission till night, and with such effect, that a Considerable portion of the Wall both of the Fausse Braie and body of the place was beat down. Nor were the Enemy idle for they kept up an incessant fire of Shot and Shells which occasioned a good many Casualties.

A 24 Pr. in No. 2 was rendered Unserviceable by being struck in the

Muzzle, several 24 Pr. Wheels were demolished, and a number of the Platforms were blown up by Shells.

Night between 17 *and* 18.—Battery No. 4 intended to form a Second breach was armed this night with 7 24 Prs., Four of which were taken from No. 1 and 2, and three Brought in from the Park.

Jany. 18.—The batteries opened this morning at day light as follows :—

No. 1, 2, 3 { 23 24 Prs. / 2 18 Prs. } against the great breach.

No. 4 { 7 24 Prs. } To breach a Tower to the left of the great breach distance about 550 yards.

The fire continued the whole day without cessation, the great breach began to put on a very favorable appearance, and in the evening it was considered practicable.

Battery No. 4 was very successful in its effect against the Tower, which by the Evening was in a very ruined state.

The fire of the Enemy was as Severe as ever, indeed they had nothing to impede them in their practice, for not a Single Shot had been fired against their batteries since we commenced.

One of our 24 Prs. burst in No. 3 from a High Shot getting jammed half down the bore, by this accident one English and one Portuguese Artillery man were killed, and two of the former, and three of the latter wounded.

The expenditure of Ammn. from ½ past Nine oclock on the 16th, to mid-day on the 18th, was 2,754 rounds of 24 Pr., and 150 rounds of 18 Pr. shot.

Night between 18 *and* 19.—Battery No. 5 in the 2nd Parallel being now in a forward state, a 5½ Inch Howr. and 6 Pr. from the Field Artillery, were placed in it this night to keep up a fire on the breach.

Jany. 19th.—At Day break this morning the batteries resumed their fire as follows :—

22 24 Prs. / 1 18 Pr. } against the Main breach.

7 24 Prs. against the Tower Do.

In the afternoon both breaches being Considered perfectly practicable, the fire of the batteries was turned on the defences, and Continued till the Columns were about to move on to the assault.

The Expenditure of Ammn. from mid-day on the 18th till the period of the assault was 3,406 rounds of 24 Pr. and 75 rounds of 8 Pr. Ammn., and the whole Expenditure of Ammn. during the Siege was as follows :— 24 Pr. Round, 8950 ; 18 Pr. Round, 565 ; Barrels of Powder, 834.

There remained three 24 Prs. in the Park that were never brought into the Batteries.

From the Casualties and Severity of the duty, it became necessary in the two last days to call into the batteries part of the Detachments of Divisional Artillery attending the Siege, in consequence of which Captain Alfred Thompson and Capt. Sympher served in the batteries

successively with part of their Brigades, assisted by Lieutenants Johnstone and Ingleby of the Royal Artillery, and Lieutenants Schulzen, Riefkugel, and Blumenbach of the German Artillery.

The Field pieces in No. 5 during the night of the 18th, were under the direction of Lieut. Smith of the Horse Artillery, who kept up a Vigorous fire.

The Columns for the Assault were accompanied by Detachments of British and Portuguese Artillery, under Lieut. Bourchier of the Royal Artillery, Lieut. Blumenbach of the German Artillery, and Lieut. Joze da Silva of the 1st Regt. of Portuguese Artillery, all which Officers were Volunteers for the duty.

The killed and wounded of the British German and Portuguese Artillery during the Siege were as follows :—

	Killed.				Severely Wounded.				Slightly Wounded.			
	Officers.	Sergts.	Rank and File.	Total.	Officers.	Sergts.	Rank and File.	Total.	Officers.	Sergts.	Rank and File.	Total.
British ...	—	—	1	1	—	—	6	6	2	1	17	20
German ...	—	—	1	1	—	—	1	1	—	—	2	2
Portuguese	—	—	6	6	—	—	10	10	2	—	25	27
Total	—	—	8	8	—	—	17	17	4	1	44	49

Killed	8	and considering the number of pieces of Ordnance bearing on the attack, and that 12,000 heavy Shells fell on so small a space, the Casualties were not very great.
Severely Wounded ...	17	
Slightly Do. ...	49	
	74	

Names of Officers wounded.

Captain Power	Slightly
Captain Dynely	Do.
Lieut. Antonio da Costa e Silva	Do.
Lieut. Alberto Joze Guerseiro	Do.

Lord Wellington in his dispatch expressed himself well satisfied with the Conduct and exertions of Major Dickson and the Officers and men under him, and he particularly mentioned Brigade Major May, and Captains Halcombe, Power, Dynely and Dundas of the Royal Artillery, and Captain Cunha, Lieut. Costa, and Lieut. Silva of the 1st Regiment of Portuguese Artillery.

Lieut. Francisco Pedrozo Barreto, of the 4th Regt. of Portuguese Artillery, deserves also to be mentioned for the zeal and good conduct he displayed on all occasions.

In concluding this detail, it is but Justice to notice Mr. Butcher, Assistant Commissary of Ordnance, in charge of the Battering train, who materially assisted in the operation, by his activity, exactness, and good arrangement.

A.D.

(*To be continued*).

A LADY'S EXPERIENCES IN THE GREAT SIEGE OF GIBRALTAR (1779–83).

BEING THE DIARY FROM 1ST JUNE, 1779, TO 13TH JUNE, 1781, OF MRS. GREEN, THE WIFE OF LIEUT.-COLONEL GREEN, CHIEF ENGINEER OF GIBRALTAR (AFTERWARDS LIEUT.-GENERAL SIR WILLIAM GREEN, BART., CHIEF ENGINEER OF GREAT BRITAIN, 1786—1802).

(*Continued*).

Saturd 25. Easterly wind, a fine Day. Find myself but very indifferent, am very much out of Spirits on many accounts, as I meet with many Vexations which I did not expect. 25th March, 1780.

Sund 26. *Easter Day.* Easterly wind. A very fine Warm Morning. I walked out before Dinner with the Child, find myself very indifferent whilst out and come home very Low. A Man of the 39th and one of 73rd Deserted last Night from the Back of the Hill. We were quite alone in the Evening. I went to See Mrs Lewis this Day. The Small Pox in many parts of the Garrison. No Innoculation allowed of as yet.

Mond 27. Easterly wind, very Dull indifferent Day. The Colonel exceedingly displeased with publick Business, and still more after Breakfast continued greatly displeased all Day. He went to the American Club. N.B. This is the first Meeting of the American Club.* He is President. Came home at 9 in the evening in tolerable spirits. It began to Rain in the evening. Children Dieing every Day. George taken very ill in the Evening; pain in foot.

Tuesd 28. Easterly wind. It Blow'd and rain'd exceedingly all Night, and so bad a Morning that the Review of the 12th was obliged to be put off. It continued a very Wet Day. Hear that Colonel Mawhood has broke his Arm by a fall as He was going to the Southward last Night. The Same discontent in the Colonel and the same Causes. N.B. This Circumstance first began by an affair of Lt Skinner's, relating to Some few Libertys taken concerning the Cattle. N.B. Capt Evelegh has got a piece of Ground allotted to him, the same where The Wind Mill was first put up, which was begun and fail'd; all Under the Direction of Capt Evelegh.

Wed 29. Easterly wind. The Morning pretty fine. Hardenburgh's Regt Reviewed. The Day continues good. A visit from Col Ross. George still ill in his room.

* See Sept. 14, 1780.

30th March, 1780. *Thursd* 30. Easterly wind; a fine Morning. The 52nd reviewed. The Gov^r has given the name of Mill Mount to the piece of Ground which he has given Capt Evelegh. N.B. It is where that Gentleman had Erected the Windmill, and without any Success. Several Ladies at the Review.

Fry 31. Easterly in Morning; turn'd out a very fine Day. The 39th reviewed, and to the Astonishment of every Body Col Ross attended as Lt Col to the Regt. He had never been with them at any of their Field Days, or done any Duty, for Many Months. It was not known to any of the officers that He would be there; but just before the Regt went on He sent to Col Kellet and inform'd him He had let the Gov^r know He intended to fall in with the Regt. In the same time Genl Boyd* went on to the Parade but never Joyn'd the Regt, only as a Spectator as on other Days. The whole went on pretty well; better indeed than it could be expected, as it was very Reasonable to think the men were taken at a disadvantage by the changing the Commanding officer that very Morning. There was no Regimental Breakfast, every body went as they chose. The whole Regt dined as others have done at the Gov^rs. Genl Boyd also dined there in his General's Uniform with his Aid de Camps, not making himself Colonel of the 39th the whole Day. All pass'd very well, but he or Col Ross did not speak to each other. Many People think these two Gentleman will never Settle the Coolness that is between them; as the Dislike seems to increase. They are both very Valuable Characters. In the Evening Colonel Ross came here. I was alone at the first; and as Usual heard all the Story. All Ended Well.

During the course of this last Month the Enemy may have been rather Slow in their business of all kinds. Towards the last few Days they seem beginning to show more Spirits. Certainly they are not going away. Would to God They either would leave us or show themselves in Earnest. We cannot be said to enjoy any great degree of Ease or Comfort just now. The kind of Necessity that the Gov^r has found out to change the Provisions has occasioned a great deal of discontent. The Troops never objected to any Method when an appearance was of a Serious Nature, but now they seem to think it hard to be obliged to eat so much Salt Fish when it is Well known there is an amazing Quaintity of Beef and Pork! Salt Fish without the proper Sauces is but poor Diet, and particularly in the Hott Season now coming on.

Saturd April 1st. Westerly Wind. This Morning was very fine. A Hanoverian Regt, Redan's, was Reviewed. All very Well. A Deserter came In from Spain, the Wolona Guards. Colonel and Mr.

* General Boyd was Colonel, and Colonel Ross, Lieut.-Colonel of the 39th.

Holloway dined with Lt Cuppage. George still Confined to his Room. Gun Fir'd at 9 oclock this Evening. 1st April, 1780.

Sund 2. Westerly wind, a fine looking Morning. Set down to write letters to England in hopes the Store Ships will sail soon. The Guards Mount at 7 in the Morning. N.B. Every Sunday there is the Same kind of publick Works going on as on Week Days, and a Continuation of many Unpleasant Circumstances. This Morning the Enemy Seem to have large Quaintities of Straw and other Stores landing at the Usual Places; by which it does not appear as if they had any Idea of leaving the Camp. We now most heartily wish they would show their real Intentions.

Mond 3. Westerly wind. The *Porcupine* Frigate sail'd last Night for Minorca and Algiers, on board of which was Mr Wilks &c, and Mr Davisson. Genl Boyd sent Us a very fine hind Quarter of English Mutton yesterday. George still very ill and confin'd to his room since this Day Week. Doctor Baynes informs me that the Small Pox broke out upon a Man of the Highland Regt on Fryday last. N.B. This is the first Soldier that has got that Disorder. At this time there is a Number of Children ill with it. Captain Knowles a Master of a Transport Well known in Gibraltar, and who has been here a long time, Died rather Suddenly. It Rain'd this Evening. It is now Supposed the Gov^{r} will allow of Innoculation, as He has said He would have no objection to it whenever the Troops took the Small Pox.

Tuesd 4. Westerly wind. A Review of the 56th Regt. A fine Morning. Charlotte was greatly indisposed all Night quite Burning with Heat. I gave her one of the Small Pills, and she Grew very ill afterwards. Doctor Baynes is of the opinion she is Breeding the Small Pox. The child has not been quite Well these last Ten Days. She continued greatly indisposed all this Day and was Bath'd in Warm Water going to Bed.

Wed 5. Westerly wind. De la Motts Regt Reviewed. This Morning the *Fly* Pacquet Boat came In from Barbary, brings a few Fowls, oranges, and onions,— all Selling exceedingly Dear. Fowls 2 Dollars a piece, oranges half a Rial, onions 2 Rials pr pound. Brings Word that the Brig belonging to Mr Mowbarry and Mackellar was drove into Tetuan Bay two Nights agoe by contrary winds as she was coming over and is now safe there. Charlotte much better in Evening and the fever most over. George exceeding ill.

Thursd 6. Westerly wind. This morning 2 Market Boats came In from Barbary, bring a happy supply of Bullocks, 36, and Some Fowls, Oranges, &c, all Selling very Dear, Fowls 2 Dollars, and upon the whole full as dear as that which came yesterday, says that the Brig is still in Tetuan Bay. They bring good News of some Engagement which was confirm'd by a Servant who came from the Consul (Mr Logie) to our Gov^{r} to inform him that our Fleet had an

6th April, 1780. Engagement with the Spainiards going home from hence. Charlotte had a very good Night and continues quite well to Day. George exceedingly ill and in Violent pain, not able to Move in his Bed without help. A Deserter came In this Morning of the Wolona Guards. The Soldier of the Highland Regt is well and has had an exceedingly fine Sort of Small Pox. No Innoculation allowed of as yet. Most People are displeased at this as it is certainly much better for the men and poor children to have this Disorder now than when it is Warmer. For my own part I am exceedingly Anxious for our Dear little Girl; and did it depend wholly upon myself I would not ask any leave.

Fry 7. Westerly wind. The 58th Review. Hear a further account of the Engagement between our Fleet and the French going from hence to Engd. Also We hear that Sir George Rodney was at Madeira upon the 19th of Febry. He sailed from hence upon the 14th. The Colonel dined at Genl Boyd's this Day. Mr Holloway with me. George continues exceedingly ill. Charlotte quite well. The *Fly* Pacquet Boat went to Barbary this Evening. The Fowls 20 Rials a piece.

Saturd 8. Westerly wind. The 72nd Review. Bought some Veal for which I gave 6 Rials per lb. Resolve to go to the Mount as the Weather was so fine. George still Confined to his Room. Got a New Hat and Silver Band &c for the Postilion. We have not bought any of the Fowls. The Col: not exceeding well pleased at the Mode of carrying on Business. N.B. Nor is any of the Commanding officers satisfied,—so little attention shew'd to Them.

Sund 9. Westerly wind, fine Morning. Went to the Mount in the chaise to Breakfast, took Charlotte and her Maid staid there till Tuesday Evening. On Monday a Boat arrived from Barbary, brings Word of a Certainty of our having had an Engagement with the French, and also that an English Fleet was hourly expected at Cadiz.

Mon 10. Cold Westerly wind. George rather better.

Tuesd 11. Westerly wind. Nothing particular. Small Pox raging very bad, children dying every Day. Din'd at the Mount and came Home in Evening on account of some Business. Find I have a Cold in my Head. Commodore at the Mount.

Wed 12. Westerly wind but rather Cool. Great Uneasiness about some *Engineering* Business, the Colonel much hurt at it and had some *particular conversations* with Capt Phipps and Capt Evelegh &c. The Small Pox increases. I am very much indisposed in the afternoon. This evening about a Quarter after 8 we were all Surprised by the Alarm Drums Beating. We had several Gentlemen in the Parlour, who all Run out, but soon returned bringing Word it was nothing of any Consequence, only a Fire amongst some Shavings of Wood in an out House belonging to the Convent, Supposed to

have been set on Fire by a Squibb from Some Children at play. This Night about 11 oclock Capt Leslie of the *Enterprize* fired 4 or 5 Guns, not known at what ! 12th April, 1780.

Thursd 13. Westerly Wind. This Morning at Gun Fire two Market Boats, or rather one, the other being the Privateer, *Saucy Jack*, arrived from Tangier with a Packet of Letters and some Bullocks, Fowls, and Oranges &c. We Rec[d] some letters and 4 News Papers. I had one letter from My Daughter Nicolls, dated Jan 28th by which We learn that our Son's Commission of Captain was dated 24th Decr 1779. Our oldest paper dated 15th Jan. the latest Feb 5th. All well in our Family at that time. The Colonel also Rec[d] his acct from his Agents. I have had a very bad N[t] and am Lame, exceedingly ill so as to keep my Bed, fear I shall grow worse as the Complaint seems to increase in all Limbs.

Fryd 14. Westerly wind. A Deserter came In, brings a confused account of the Enemy's Intention to Advance. I went down to dinner but found a very great pain in my Left Knee. Quite alone in evening. Several Guns were Fired in the Bay at 10 oclock at Night.

Satard 15. Westerly wind. Find myself growing exceeding bad ; a most Violent Headache ; likewise my Leg and Knee, could not get up. Hear that the Firing was occasioned by the Arrival of the *Hyena* Frigate from Eng[d] 20 days from Portsmouth. Capt Thomson has brought very Particular Dispatches for the Gov[r] and Commodore Elliot. We hear she is likely to go back very soon ; must therefore try to send home some letters if it is in my power to write ; but I now keep my Bed, not being able to bear the Moving. I sit up and wrote a long letter to my sister this Morning and inclosed one I had wrote in part since the first of this Month to my Mother. This was all I could do to Day. I Rec[d] a letter by this Frigate from Lady Rich from Portsmouth ; fear it will not be in my power to Answer it as I am exceedingly ill.

Sund 16. Easterly wind. The Frigate seems likely to be going. Every Body is hurrying to write letters. The Colonel Busy in getting Public papers ready. I sit up in bed and write a long letter to my Son on his Promotion. This Day my pains moved into my Right Leg and nothing can exceed the Agonies I am In. An other Deserter came In, brings In a further Confirmation of the Enemy's Intention ; in bed all Day.

Mond 17. Westerly wind. Ships not gone. Am worse this Day than yesterday, and at Night beyond all possibility of bearing it with any Degree of Patience. The Small Pox Raging greatly and has got among all the Regts. A Man of the Soldier Artificers exceedingly bad with it. No Innoculation yet !

Tuesd 18. Westerly wind. Have had the Worst Night I ever experienced in my Life. Write this in my Bed. Continue exceedingly bad at Day and at Night.

19th April, 1780.

Wed 19. Easterly wind. Not able to get up. Take Dover's Powders. Ships not gone. The Garrison very Low and Dull.

Thursd 20. Easterly wind. The same. The *Edgar* Commodore Elliot and the *Hyena* Frigate Capt Thomson sailed, and in the afternoon Admiral Barcelo went out.

Fry 21. Easterly wind. *Colonel and Gov'* upon the Parade. Find myself a very little Easier. Take more of James Powders; can not sit up yet. The Man of the Highland Regt Recover'd.

Saturd 22. Westerly wind. Seem a little Easier; set up a part of the Day. The Man of the Artificer Company very bad.

Sund 23. Westerly wind. I was taken up in the Course of the Day but not able to Stand. 7 Men Died of the Highland Regt between last Night and this Evening, of a Flux and Fever. They had lost near 100 before. Barcelo return'd to Algezira. This Even about 8 oclock a very bright and Remarkable Meteor was seen in the Sky, resembling a burning, flying Kite,—Viz., a Blazing Star; Seem to take its direction towards the Queen of Spain's Chair. Find myself tolerably Easy when going to Bed. My Foot greatly swelled.

Mond 24. Westerly wind. Had a much better Night than I have of late, tho' did not Sleep but very little after 3 oclock. Got up at 11 but only could be set in a Chair by the Bed Side. Rather low all Day. Barcelo has return'd back to his Station two Days. The Small Pox exceedingly raging; Children also Dieing. Hawkins of the company very bad with it.

Tuesd 25. Westerly wind. My Lameness no better; but had a little Rest last Night,—not a bit better able to Move. Set all Day in my Chair, between Window and Bed. Charlotte got a bad Cough. Mackellar's Vessel arrived on Sunday from Barbary.

Wed 26. Westerly wind. Did not Sleep quite so Well but find my Leg rather Easier when I got up. If I continue so to Morrow, mean to be taken into Dressing Room. This Even Hawkins died. Col: and Mr Holloway dined at Genl Boyd's, Supt at Phipps. This Day a Spainish line of Battle Ship anchor'd near Point Negro. She remained all Day and Evening.

Thursd 27. Easterly wind. A Boat arrived from Malaga, last from Tangier, with oranges, Eggs, and oil. She is going to Farro. This forenoon Don Barcelo and two Line of Battle Ships got Under Sail and went towards the West. I came out this Day to my Dressing Room, being brought out by two Women, after having been in my Bed Room 14 days, Wrote some more in a letter to my Daughter Nicolls in hopes to get an opportunity to send it. N.B. I did not mention that the Troops had Soft Bread issued out to them upon the 24th for the first time since the Fleet left us, (they having had Biscuit all that Period). Great complaints now making about Salt Fish.

Fry 28. Westerly wind. Hear that Barcelo was return'd, and also that all thoughts of the Store Ships going was over, it being impossible to let them have any Convoy. A Boat arrived from Malaga yesterday that is to go to Portugal as soon as possible. Very Lame still. 28th April, 1780.

Saturd 29. Westerly wind. Obliged to be brought out the Same as before. Much confused talk of the Enemy's Intention to Fire upon the 1st of May. They are landing Stores of all Sorts at Point Negro. This Day and for these Days past the Colonel has been rather Low and Dull, owing to many Unpleasant Circumstances in business.

Sund 30. Westerly wind. Brought out again by the two Women. N.B. I try'd all I could in the Course of Yesterday to assist myself and Strove all that my Strength would allow to Stand, but it was attended by my growing a great deal Worse for it. The Same Unpleasant talk of to Morrow Firing. This Evening about half past 9 a Sudden Fire broke out in the Enemy's Camp. We did not at first know what to make of it. It continued to burn very Smartly indeed for half an hour. It appeared as if it was behind the Camp. We heard their Drums beating most of the time. N.B. Upon the 16th of this month the following Memorandum was given to the several Adj^{ts} at Orderly time, but it was not put down as Orders. I was then so ill that I omitted to set it down in its proper place.

"The Governor permits all officers who have enclosed and Cultivated ground to keep it during their residence in the Garrison on Condition that they shall send to the publick Market all the produce they do not make use of themselves and that they do plant Trees."

Various opinions form'd in Consequence of the above; to think what could induce the Gov^{r} to give out such Recomendations, particularly as he has encouraged Several officers of late to enclose Grounds &c, and also giving so large a place upon the Mountain to Capt Evelegh, and also at the South to Capt Witham. However it cannot affect Us at the Mount; ours being upon a different footing, as the Colonel pays a Yearly Ground Rent into the Revenue, and We do not allow ourselves to think the Gov^{r} has anything to do with our property. Mount Pleasant has now been near 5 years improvement and may most likely turn out of the Utmost advantage to the Garrison.

Thus ended the Month of April, and it is not very Easy to tell how exceedingly Uncomfortable all Ranks of People now are. This Circumstance of the Generals Refusing to allow of Innoculation has hurt all degrees of People. Several Men are quite Miserable at not being allow'd to Innoculate—12 men in one Regt were anxious—and it is the More to be Wonder'd at as the Gov^{r} did actually say He would not have any objections if it once got amongst the Troops, which it has now; and likewise has been already fatal.

1st May, 1780. *Mond May 1st.* Westerly wind, not so bright a Morning as of late. All has remained perfectly quiet from the Enemy, so that very little is to be depended upon from what is mentioned by flying Reports. We can plainly See where the Fire was last Night. It is in the Rear of the Camp amongst some Hutts, most likely Sutlers Hutts, and little shops. There seems to have been a good Many Burnt, indeed it was a very considerable time Burning, and We know they could have no Supply of Water. This Day keeps very Dull and Hott, looking like Rain. Various Reports still with Respect to the Enemy's Intentions, and the Inhabitants, Idly giving Way to their fears are all flying out to the South. This was the Second Monthly Meeting of the American Club. The Colonel was not very Well; however He went and Return'd in the Evening perfectly cool, and better than when He went out. About 7 it began to Rain and continued a fine Shower till 10, when I write this. My Lameness still very Troublesome, not being able to stand. A General Court Martial this Day upon a Man of 39th for theft, Col Cockran President.

Tuesd 2. Westerly wind, a pleasant Morning. Here the Enemy are busy landing Mortars and all sorts of Stores at Point Negro. Find myself very little better as to my Lameness; and am very Low spirited most of this Day. Mrs Phipps &c call'd. Col: pretty well. This Morning Doctor Baynes tells me He has been with the Gov^{r} and had talked with him about the Small Pox, and asked him this one Question; If it happened in a family where there were More than one child, would it not be a better Way to Innoculate the Rest of that family? as it was not to be doubted They would get it, and it would be the means of its being Sooner over. He answered: No; by no means! He could not answer it to his Conscience. What the Gov^{rs} Meaning is I know not; but I do think He ought to make a point of getting this cruel Disorder as soon over as possible well knowing the Violent Season coming on; and also to comfort many anxious Parents and others.

Wed 3. Westerly wind. Am still Lame. The Colonel not very Well and did not go to Parade. Many Idle Reports about the Enemys advancing and it was actually said They had begun to throw up Ground on this Side the Lines; and that two Engineers were seen in the Round Tower, as it is call'd, upon the Neutral Ground. It was afterwards Well known it was two Dogs that had been hunting about and had torn up the Ground. I saw the very officer who first observed them and absolutely distinguish'd the Different Colours of those very Dogs,—the officer at Forbes Guard,—He call'd up to the officer at the Lines and told him what it really was; but he was displeased and ask'd if He was not a Judge between 2 Dogs and 2 Men, upon which He (the officer at the Lines) made his report to the Gov^{r} who sent Word to the Capt of the Batterys that if He

observed any Troops, or even Partys to assemble on this Side their Lines, that He should fire all the Guns that He could bring to bear that Way. However all Remained perfectly quiet. 3rd May, 1780.

Thursd 4. Easterly wind early this Morning. I finished a letter to My Sister and sent that and an other to my Daughter Nicolls which I finished Yesterday (tho' I had begun it to her upon the 20th of April) and inclosed them to Lt Amphlett of 39th as it is expected He will go in a Boat to Farro this Evening. The Col: had a Walk to Rosia this forenoon, did not come home till near three, which according to Custom Tired him, and he was very much out of *Sorts* in the afternoon.

Mem^m^. It was an Unpleasant afternoon. My Leg has been in a good deal of pain all Day. N.B. Every Day there are children Dieing with the Small Pox and also a very bad Fever. The Man of the 39th is to be Executed on Monday. The Col: very much *disturb'd* in Even. My Leg grew Violently bad at Night, obliged to be carried by all three Women to Bed.

Fry 5. Easterly wind. Lt Amphlett went last Night. Find myself very indifferent indeed, but for many reasons resolve to keep up my spirit if possible. Our little Daughter Seems very heavy and Dull to Day. N.B. I had been keeping her upon a Low Diet &c, &c, and she has taken three Preparatory Pills. She seem'd feverish at Night. The Colonel staid at home all afternoon and Seem'd more Composed, tho' very Low. Not quite so Lame myself this Evening.

Saturd 6. Easterly wind, exceeding Warm Day. It is Dreadful to hear the Number of Children that are Dieing. Charlotte very Heavy and Dull all Day, not able to hold up her Head. We are exceedingly Anxious, indeed I am quite Miserable from Fears. This afternoon the Enemy had a very grand Review, and keep up a Sort of Fight for two hours, with Horse and foot, taking Possession of all their Neighbouring Hills. It seemed to hurry the Garrison a good deal. The Gov^r^ at our house a long time this Day, looking at planns and in Conversation with the Colonel. The Col: and he went to the Castle and Lines afterwards. Some new Work is going on there. Charlotte very hott at Night.

Sund 7. Easterly wind. The Col : up at 4 oclock and out with the Genl, did not come home to Breakfast. Abundance of Children Dies with the Small Pox. Charlotte very bad and sleepy all Day. This is the 2nd Day she has been so ill. On each side of our House and Directly opposite three very fine children have Died since Yesterday after being 9 Days bad. Serjt Grant's little Girl died this Day of the Small Pox, about the 9th Day. The kind of Small Pox now chiefly going is a very Dangerous one. Doctor Baynes seems to think our child will get it now, indeed it seems an absolute Certainty as it is in every House in our Street, and in the opposite Door. The Col: and Mr Holloway Dine at Capt Vignolles. Charlotte very ill

7th May, 1780. in Evening. A Flagg of Truce from Spainiards today and a parley from them yesterday, Just before the Firing. Find myself Under the Necessity of forcing all my Strength in order to keep up, as I fear I shall have a call for all my Exertion. Towards Night the Child grew Violently bad and inclined to Startings. I greatly fear for fitts. She keeps calling for me chiefly. She was Bath'd in Warm Water.

Mond 8. Easterly wind. Charlotte had an exceeding bad Night and is quite Delirious to Day. Dr Baynes has no doubt of its turning out the Small Pox. In the Evening We observed some Spotts coming out, and she grew more cool and composed. She is kept in the Air, and Drinks Cold Drink, chiefly Toast and Water.

Tuesd 9. Easterly wind, very Warm Weather at this time. The Enemy very quiet. Our Child going on in a good Way. Seems as if she would have a good sprinkling, tho' Doctor Baynes says they will be of a good kind.

Wed 10. As the Enemy was tolerable quiet now and as Nothing very Essential occurred, I was not so Anxious to set down every little Movement which they made in loading or Unloading Small Boats which were Daily going backwards and forwards to the Orange Grove. My chief attention is now to my Dear child, who thank God goes Well on.

Thursd 11. Going on well, but very sore, and bad Nights, Still every thing appears well. She was very patient, tho' in a good deal of throbing pain.

Fryday, Saturday and Sunday. In the Same Way. Her Nights very Restless, Notwithstanding her taking opiates. On Monday they were at the height and highly Inflamed. On Wed they all turn'd and on Fryday took Physick. All the next week continued doing Right and had hardly any Second fever which is common upon the Turn. Everything was over even to the last of her Physicking, and she was put into a Bath of Warm Water and Herbs upon Saturday Evening 20th May. We have great Reason to be thankful for this Blessing; as during the Course of this last fortnight, not less than 40 Children have Died of this Dreadful Complaint; and also Soldiers,* and the air is now quite full of the bad Infection. A very Dangerous fever is also in the Garrison. All this time Every Means have been tried to obtain the Govrs Leave to Innoculate, but to no purpose. Every Body appears Unhappy, and are Dreading the approaching Warm Months. Not any fresh Provision comes near us now; So that we are badly off indeed.

Sund 21. Easterly wind, a fine Day. I went out to the Mount with the Child for the first time. It was a very Warm Day. Took a Ride after dinner to Europa. Drank Tea at the House in Town.

* The two-volume version of the diary says "More than 50 English Children have Died and Several Soldiers besides Inhabitants."

The Col: not very Well Just now. A Man of the Artillery fell down at Europa and Died as they were bringing him into Town. Several Gentlemen here in Even. My Maid Eliz^th^ Dixon taken not well.* 21st May, 1780.

Mond 22. Easterly wind, fine Day. Took an Airing to the Southward after Dinner, with Mrs Phipps who return'd to my House. My maid ill, but as We had all the Reason to suppose she had the Small Pox some years agoe, so we had not any fears. Abundance of people ill with the Small Pox. Every Day 5 or 6 Buryings, and every body Alarmed and Unhappy on that account.

Tuesd 23. Easterly wind. Charlotte quite well. The maid much Worse, a high fever. Doctor Baynes is as attentive to her as he was to our own child. The Col: out in Evening. Not well myself.

Wed 24. Easterly wind. No fresh meat kill'd in the Market. Doctor Baynes pronounces the Maid's Complaint to be the Small Pox. Great Uneasiness on that occasion. Thinking she had had it long before, therefore she was no ways prepared. We put her into a most charming airy apartment.

Thursd 25. Easterly wind very Strong. We are greatly Distresst in our family. The Young Woman very bad. I am particularly hurt at it as she now wishes She had been Innoculated. I am too much distresst to keep any publick Journal. Indeed it does not become Necessary, as most things remain in the same Unpleasant Way, the Spainish Admiral doing his Utmost to keep up the Blockade. However We sometimes get In a Boat with a small supply. Every thing at this time as Dear as ever; nor is there any method taken to have it otherwise. The Gov^r^ says he has not any objection to have the Fresh Meat as dear as possible. It is not very easy to know his Reasons for it,—Contradiction only! We kill'd a fine sheep this Day; sent a Qr to Genl Boyd. The Rest was used in our House. We had Company the Rest of this Week. We are now obliged to kill a sheep when ever We wish for Fresh Meat; which is not of half the Use to the family as it would be in Cooler Weather. We therefore now Exchange with General Boyd's family, each of us having Settled it not to kill Sheep together.

From *Thursday 25th of May to Thursday 1st of June*, Nothing happened in the public Way. Our Servant Maid is past all Possibility of Recovery. Every Means is try'd but we find it will not Do. Men, Women, and Children Dieing every Day and the Utmost Distress now appears in every Body. The air is full of this Cruel Infection. It is to be wished that the Innoculation had been allowed. That would have stop'd this Weeks agoe.

June the first. All the Same Dreadful Situation in our House. I did not Stir out. Our Clergyman, Mr Logie Died about this time. The Weather most Violently Hott.

* At the end of the MS. volume is a full journal of the progress of this maid's illness.

2nd June, 1780. *Fryd 2nd.* Easterly wind. The whole Family indisposed and in trouble. The Colonel went to the Mount, and staid to Breakfast at Colonel Trigg's, also He Dined there; a very great change in the Maid for the Worse, just at half past one. N.B. From that instant there Remained no possibility of saving her, as she continued in a Dieing State.

Saturd 3. Easterly wind. Still Worse and Worse. Find myself very Lame. Baynes here as usual. At Noon she Seemed going, but Recover'd again.

Sund 4. Easterly wind. King's Birth Day. The Gov^{r} received the compliments of the Garrison upon the Grand Parade at Guard Mounting,—42 Guns Fired at one oclock, and all the Field officers, the Staff and the Navy Din'd with the Gov^{r} in his Garden. This was all the Ceremony observed on this Day!

At 20 Minutes before 3 all was over with our Maid Servant, upon the 15th Day from her being taken ill. It is a Most Unwelcome Circumstance and has greatly affected the Colonel; I am not able to tell what I experience. I was exceedingly ill and hardly able to move.

Mond 5. I went out to the Mount, took the child and Mrs Rogers, staid there till Evening. She is quite hearty and well; Seems Much to Miss her Maid and says she knows what has happened. She is old enough to know all that has pass'd. Charlotte was five years old in March.

Tuesd 6. Westerly Wind. Bustle and hurry in the House and many Unexpected Difficulties occurr'd, particularly relating to our Servants. In the afternoon the Ccl: sent to our Servant Man James and Discharged him at that time; the Man's children were in the Small Pox.

More and More bad accounts of the fatal Effects of the Small Pox, and Many Severe things said in consequence. It cannot be Wonder'd that the Lower Degrees of People should be much hurt at all these bad times, their Provisions so bad, Nothing to be got to assist them or their poor familys, and the Losing so many fine children, has been a heavy Stroke upon them, but We hear that a great Person in the Garrison says he thinks it a fortunate Circumstance to those Soldiers who have Large familys to Lose three or four Children!

Wed 7. This morning at half past one the Garrison were alarm'd by the appearance of some Fire Ships coming over from Algezira. The Drums beat to Arms; and the Garrison fir'd from every part of the Line Wall where they advanc'd. There was 9 in all. Most fortunately for Us the wind faild and they were obliged to light these Ships Sooner than they meant. They were all driving towards the back of the Rock. It was a most Grand tho' Alarming Sight as they burnt with great Violence. It seemed to me just so Many Moving Mountains of Fire! Every Regt was at their Alarm posts and it was generally

expected the Enemy would Fire from their Lines. I little expected such a Shock but I believe I am not Born to partake any very Common Fate; otherwise I must have long since ceased to Exist, considering all I have experienced. My heart now seems totaly full of Concern and Vexation; my bad State of Health has rendered me Miserable. Nothing but Women Servants about me. The first Moment of the Alarm the Colonel went away from the House. To hear the Drums beating, the Noise of the Guns from the Garrison and all our Ships, together with the bursting open of the port holes in the Fire Ships, was beyond the powere of my Pen to express! I was actually Stupid with Fright,—and at that Dead time of the Night also,—and Circumstanced as I and this whole family were then,—it realy was Distressing. I was even then glad to think it had not happened a few Nights before; as it would have added to our Concern if the poor Woman had been Sensible of the Circumstances. 6 of these Fire Ships ran on our Rocks and 3 were drove behind the Mountain and got away. Our Men of Wars Boats and the Ordnance Vessels behaved remarkably Well and very Cool. The Vessels continued to Burn all this Day. The *Enterprize* was the first who gave the Alarm of their coming as it was the Guard Boats from that Frigate which Hail'd the Spainish Boats which Were coming with the Fire Ships. The English officer ask'd what Boats and Vessels? they answer'd Beef Boats from Barbary! He told them He did not credit it and Instantly went on board the *Enterprize*. The Frigate fir'd one Gun, and not being answerd, they Fired as quick as they could, upon which the Enemy Set Fire to the 7. There were 2 at a considerable Distance, but had no Effect. The bustle lasted till near four and then the Regts were all Dismiss'd. It rained Smartly about 7 which greatly pleased Us; but the 2 Largest Fire Ships continued on Fire all the Day. One was Drove near to Rosia Bay where the *Panther* Lay, and got In between her and the Shore. It was very Evident the Enemy meant to set fire to the *Panther* and to the New Mole. Thanks to Providence They were Disappointed. May they always be So. I was, as well as many others, much affected with this unexpected alarm. Col: dined out. Mr Holloway with me. 7th June, 1780.

Thursd 8. Westerly wind. All quiet from the Enemy. Find myself greatly indisposed and very Low all Day. Had a little particular Conversation with Mr Holloway,—not of any use after all.

Fry 9. Westerly wind. Still very Low and ill. Two or three boats arrived from Tangier, brought letters and News papers. N.B. Not any for Us. *The Man's* child Died.

Saturd 10. Westerly wind. All the Same in the Camp &c. Very ill. Settled to dine at Mt to Morrow.

Sund 11. Westerly wind. It began to Rain about 8 in the Morning, continued to do so till Noon. It then cleared up and I went in the chaise to the Mt. Was very ill when there and could not Walk

11th June, 1780. out. Return'd at Nt. A good many in evening. 2 Market Boats from Tangier; Beef and Mutton.

Mond 12. Westerly Wind. All quiet in Camp. Worse and Worse in the Small Pox. Have had 3 exceeding bad Nights and am still ill. Take a Ride in afternoon to Europa, took 2 Miss Phipps who Drank Tea with me.

Tuesd 13. Easterly wind. All the same Uncomfortableness. The Enemy took a Setee* coming over to Us with Provisions. N.B. This was contradicted afterwards. Not very Well.

Wed 14. Easterly wind. Find that all the Ships are gone from Algezira and that Barcelo has Hoisted his Flagg on board a Xebeque. He went behind the Mountain last Night. I wrote this Day to my Son and to my Sister.

Thursd 15. Easterly Wind. The Ships attempted to sail last Nt but was obliged to Return as the wind came about. I therefore sent an other letter by Mr Colvill to my sister. N.B. Those I wrote yesterday went in a public packet from the Convent, in a Boat to Farro. Colonel Green has also sent letters by Col Gledstanes, as I did one to Capt Nicolls by Capt Ormsby who went in the same Boat with Gledstanes. The 3rd Mate of the Highland Regt Died.

Fry 16. Easterly wind. The Boat made an attempt to go but was obliged to return. Col: at Dinner at Col: Ross.

Saturd 17. Easterly wind still. Changes making in the 12th and 73rd Regts. I write a long letter to Capt Nicolls and sent it by Capt Ormsby. He has sold to Lt Colt of 73rd for twenty four hundred pounds. Capt Mackintosh's Lady (73rd) Died suddenly this Day. Colonel Gledstanes goes home as is said upon account of his ill State of Health. Grow very ill in the Evening and quite Lame. Mr Cuppage call'd here in afternoon.

Sund 18. Easterly wind. The Boats not gone. The Col: Breakfasted at the Mt. I went in the forenoon to pay some Visits in Post Chaise, and afterwards to Dine at the Mt, Return'd in Evening.

Mond 19. Easterly wind, but not Strong enough to take out the Boat. Col: at the Mt in afternoon to meet the Genl. A mistake in some Money Matters; the Col came home in very good spirits, having had a pleasant Walk with the Genl. Find myself not very well.

Tuesd 20. Westerly wind. Very Warm now. The Colonel Walking in King's and Prince's Lines with the Govr to Day. He dined at Convent, Mr Holloway with me. Some Spainish Engineers seem'd Busy on the Beach taking a Survey. A Boat arrived from Tangier brings Word that the Spainiards had taken an English Vessel bound for this place from Under the Guns at Tangier. This hurts us a little. Find myself ill at Nt.

* A small sailing vessel.

Wed 21. Westerly wind. Col breakfasted at the Mt; Busy about taking in some more ground to Improve, dined at home. 21st June, 1780.

Thursd 22. Easterly wind. Dull looking Morning. Go out to the Mt after Breakfast, take Kitty Phipps, went to the Hospital, dined at Mt and came home in even. This Day it was in Orders that the Assisting Engrs and officers employ'd as assisting Overseers should be dismis'd upon the 24th Inst. Boats for Farro go this Evening, and a Leghorn Ship, on board of which was Mr Colvill.

Fry 23. Easterly wind. Find that one of the Boats for Farro is gone, and also the Leghorn Ship. Col Gledstanes and Capt Ormsby went in the Boat; Mr Colvill in the Ship. A Boat is going away to Farro this Evening, call'd the *Fox* belonging to Merchant Andersen by which I wrote a letter to My Sister; and sent it to the Convent, being resolv'd to try all opportunities. Hear that the Enemy is making some kind of Defensive Work upon their Coast, which looks as if they were alarm'd for themselves. A small Boat arrived this Day from Minorca, left the *Porcupine* Frigate there, brings Word that the Garrison was under some fear of being besieged, and that they had no Supplies from any where. This Boat brings news of Some Gun Boats coming down here from Majorca.

Saturd 24. Westerly wind. This Day at Noon Several large Xebeques and one Frigate came from Ceuta, and in a very Impertinent way came near the New Mole. The *Panther* and *Enterprize* fir'd and the *Enterprize* sufferd from the Blowing up some combustibles on board, 15 men Wounded. I went to Mount Pleasant at this time, with an Intention to Remain out for some time, my Health being very poorly and I am willing to Try every possible Means to be Well at this Sickly Miserable Period. Came up in very great Dejection of spirits, fear I shall soon feel the fatal effects of it. Greatly is every family hurt at the Daily Misery of the poor Dieing Children.

Sund 25. Easterly wind. Settling myself at the Mount. Heard no News.

Mond 26. Easterly wind. All pretty quiet. Many Boats now at Algezira. Am very ill all Day.

Tuesd 27. About half past one this Morning we were alarm'd by a Firing in the Bay. I got up, and my Windows at the Mount afforded me the Means to See much more of this attack than I expected or Desired. It was from Boats of a particular Construction, of which indeed we had Received a Sort of Information from Minorca. They each Contained one Gun and a Large Number of Men. They evidently were attempting to destroy the *Panther* and the Ships in the New Mole. It was exceedingly dark at the first and as they were low in the Water could not be distinguish'd except from the Flashes of their Guns. The *Panther* was Laying in Rosia Bay (the same station as when the Fire Ships came) and her Stern was towards

27th June, 1780. the Boats when they first fir'd. She afterwards changed her situation, trying to bring on a Discharge from her Broadside. The frigates and other ships fir'd as did those Batterys that bore upon them from Bonna Vista, New Mole, Rosia, and every where was possible to be of any use. The 2 Regts that were at the South Barracks turn'd out, the firing continued till past 2. We could now tell with certainty the Number of Boats. Some of their shot came on Shore. One fell between the Vineyard call'd Picardo's Garden and the South Pavilion; one very near to the Centinel at the Grand Magazines. As the Day advanced they all disappeared. They are very Low in the water. By 4 oclock all was over; and no hurt done at all. We were all a good deal Alarm'd. From this time and for many Nights after we were constantly alarm'd by shot firing; sometimes by the Frigate, mistaking the Watch Boats, sometimes from the Enemy over at Algezira, and this Month of June ended in Nightly expectations of More Boats, as it was now well known they mean to burn or destroy the *Panther* but we hope they will not Succeed.

Saturd July 1st. All quiet from the Enemy. Find myself growing exceedingly indisposed. Nanny Redway came to our Family.

Sund 2nd. Still ill; pains seemingly coming on; and a great Weakness all over my whole Frame; The *Second* Child Died—very sorry. Number of Signals from over the Way, and all observed with great exactness by the Camp, Queen of Spain's Chair, &c, &c. Between Sunday the 2nd and Monday Morning the *Panther* saild. It was not in the least Suspected, but no doubt was in consequence of those Gun Boats having so plainly shew'd their Intentions to Destroy that Ship. On Monday Noon a Row Galley came over from Algezira and plainly discover'd the *Intent*, which was to look if the *Panther* was in the Mole or if actually gone. It was Universally believed that Admiral Barcelo was on board in a Disguise. They came by much too near and in a very insulting Manner paraded about. It was plain to be seen that a person in a Fisher Mans Dress was the whole time looking through a Spy Glass; as Many of our officers were doing the same. He seem'd to be making particular observations, sometimes standing up. This Person was either Barcelo or some officer of Trust. Our Frigate and an other Vessel fir'd at the Galley. She kept Her Colours up the whole time and when she had sufficiently amused herself went off. A Night or two after this More Boats came over. It was pretty clear at their first appearance, and I plainly discover'd 6 Gun Boats. We fir'd very heavily at them, and they had Repeated Signals made from Algezira and from Point Negro &c which they obeyed, and after being about an hour in the Bay disappeared.

The Rest of this Month little Essential occur'd. The Same Uneasiness proceeding from the Blockade. The Enemy are tolerably quiet at Nights, only taking care not to allow any thing to go out or

to come In to Us. Provisions are dreadfully Dear and exceeding Scarce. Very bad for Sick Families. 2nd July, 1780.

Tuesd August 1st. Easterly wind. Had a very bad Night, the pain intolerable in my Hip and Back. Send In to the Col: who informs me that Baynes has promised to come out in evening, that the Col was to dine with Col Picton. Battle of Minden Day, celebrated by Col Picton, 12th Regt. All Ended in perfect Harmony. Col: came up in evening in very Easy Temper; Baynes came. In great deal of pain all this evening. Dinah came up likewise, ill with a pain in her Head and face. The wind came Westerly about Nine oclock and Blew hard. Great scarcity of Provisions. About this time Major Horsfall of 72nd sold his Cow for Fifty Guineas and a pint of milk every Day!

Wed 2. Westerly wind. Had a very painful night, could not stir myself. Take some of the pills for the first time. The Col: did not come out this Day. Betty went into Town in the Evening as George is not well.

Thursd 3. Westerly wind. Still exceedingly bad. Dinah had a Blister &c. About Noon We observed at the Gut's Mouth a Sort of Engagement between some Galleys and a Large Boat or Setee. However they were so distant We could not tell, but it is too much fear'd it is the *Fox* pacquet Boat. Whatever it was they have taken to Tangier we think or to Cadiz.

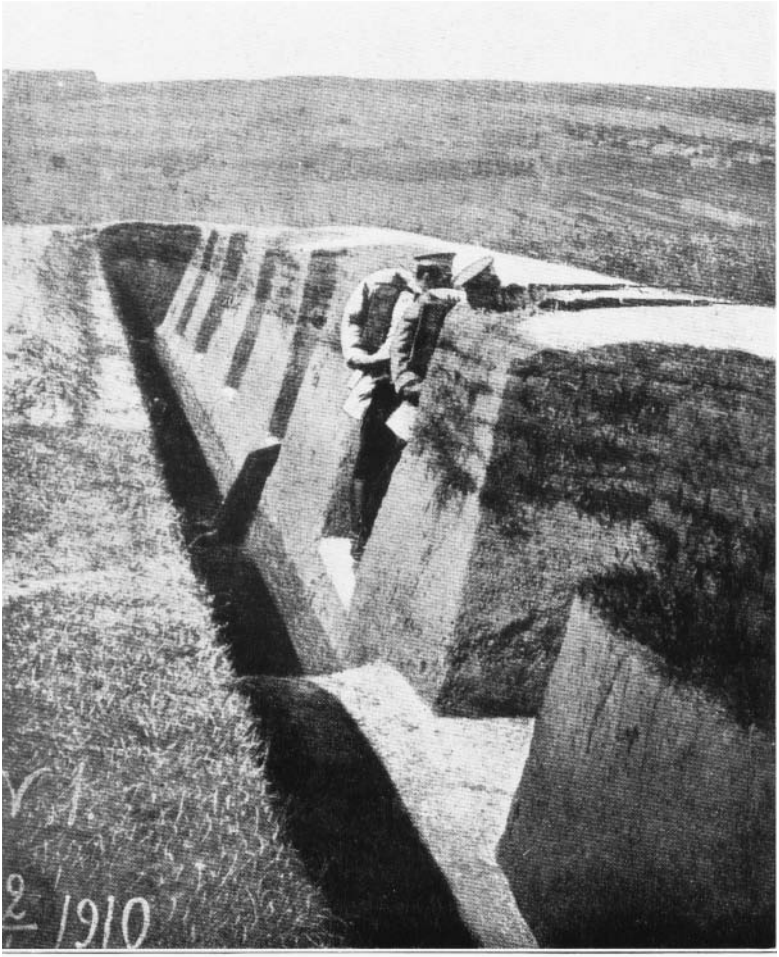
Fry 4. Westerly wind. A Setee got In with great difficulty from Minorca. She was closely follow'd by Row Galleys. She brings a Small Supply of Wine, Honey, and a few pigs. We hear about this time that the Ports in Barbary are totaly shut against Us! The Moors will not shew the least inclination to assist us. On the contrary they allow our Vessels to be taken in their Harbours. This We learn by Means of Several Parleys which have come In of late and in particular of an English Vessel's being taken a few Days agoe as she was going into Tangier, that the Passengers are gone to Algezira and that there is among them an officer of the 56th Regt and a Merchant and his Wife who are to be sent in a Flagg of Truce in a few Days.

From this Day till Saturday the 12th nothing particularly Worth Mentioning occurr'd.

Saturd 12. Westerly wind. Just after our Morning Gun Fir'd there were Signal Guns and Rockets fir'd from Caberitta point and in half an Hour a Brig appear'd coming round the point. She was chased by 4 Small Galleys. She fir'd two Guns to Us by Way of Claiming our Assistance. She was Directly known to be a Brig belonging to Merchant Mackellar, call'd the *Dolphin*, from Lisbon. He has long expected her, is Loaded with Wine, Oil, Sugar, &c. The same Vessel had been a long time in Tangier Harbour and has been twice fortunate enough to get In here with Supplies. She now

12th August, 1780. saild In with a fine wind at the Day break. Unluckily it faild at half past 4. She made for Europa. There our Batterys fir'd and from Bonna Vista, but not one shot hit the Galleys. We fir'd one Shot from the New Mole Head to encourage her. She came at last very near our guns, and We flatter'd ourselves she was out of Danger, as the 4 Small Galleys seem'd Shy of our Batterys. At this Instant 2 very Large Row Galleys came pouring down from Ceuta. This encouraged the others, so that to the Universal Concern of the whole Garrison they Boarded Her. She would not Strike. I saw the whole Manoeuvres from the very instant she first came round, saw all Her sails shot away, the Grape Shott flying all over her Rigging. The last shot carried away her Lower sails and Yards, then it was easy to Board Her, and I plainly saw the first Spainiard get on Board, it is impossible to express the discontent of the Garrison on this occasion. The *Enterprize* was in the Mole, but every Body expected all the Boats would have been arm'd and sent out, which if they had when the first signals were made from the point it is beyond all doubt we should have got Her Safe In. It certainly is the most Unpleasant Circumstance that has happened to us, and has occasioned Many Severe things to be said against our *Navy Folks.* No Wonder. We dread to hear the fate of the Captain and Crew. They must have Suffered We think. She Lay to for half an hour after they took Her, and as it was a Dead Calm and she was much hurt they Tow'd her over to Algezira. It is supposed to be an Essential Loss to this Garrison as we are in Want of every Commodity which we know she had on board. Mr Mackellar says it is a very great Disappointment. He hopes his share was insured.

(*To be continued*).



The 'Nest' or Recess Trench (full size and profile).

The Nest

TRANSCRIPTS.

"NEST" (OR "RECESS") FIRE TRENCHES.

(*Précis* of an article, by Capt. Modrakh, of the Russian Engineers, published in the *Infenerni Jurnal*, March, 1911, pp. 293—311).

THE great importance of spade work, both in attack and defence, is now universally admitted. The difficulty lies in the elaboration of a suitable type of fire trench capable of satisfying the required conditions; of which the most important are the following, viz.:—

1. The plan and profile must be such as shall admit of gradual development; at the same time affording the maximum amount of cover and strength at every stage, and *especially during the earliest stages* of its construction.
2. There must be adequate cover from enfilade fire.
3. The accommodation should provide for men acting in pairs; the file (and not single men) being regarded as the primary infantry unit.
4. Strong frontal fire must be combined with a wide horizontal range, and close adaptation to the ground.

The construction of "nest," or recessed, trenches was tested practically during certain musketry courses for officers in the summer of 1910.

The scheme provides for the construction of "nests," or recesses, (each having a frontage of 2 paces, and accommodating 2 men), at intervals of 2 paces.* Such recesses may or may not be connected by a small trench in rear for purposes of communication, but only if time permits. Such a trench might be deepened to a depth of 4′ 8″. The advantages claimed for this arrangement are (*a*) the initial stages in the construction of such cover can be completed much quicker than is the case with the (Russian) regulation pattern of trench; (*b*) the horizontal field of fire covers an arc of 120°, as against only 60°; (*c*) complete cover from enfilade fire; (*d*) the fact of two men being together more than doubles the value of each man, due to the moral support each receives from the presence of his neighbour. The strength of the firing line (one man to 2 paces) remains the same as that allowed for in the existing (Russian) form of trench.

A comparison of the *Photo.* with *Fig.* 1 (reproduced from the *Russian Official Manual of Field Entrenchment for Infantry*, 1908) will explain the difference between the proposed and existing forms of trench (specially with regard to enfilade fire).

* The Russian pace varies from 28 to 35 inches, but in this article is generally taken at 1 arshin or 28 inches.

Similarly, a comparison of *Figs.* 2 and 3 will show the enhanced field of lateral fire, afforded by the proposed recesses.

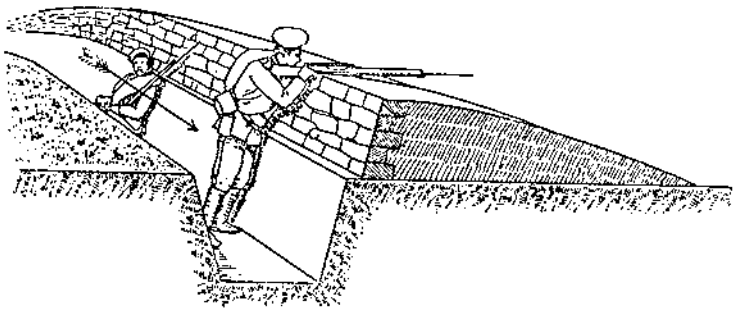


FIG. 1.—*Fire Trench (Russian Regn. Pattern).*

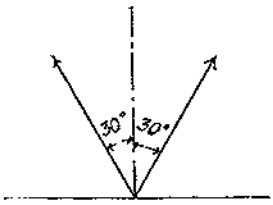


FIG. 2.—*Lines of Fire in Ordinary Trench.*

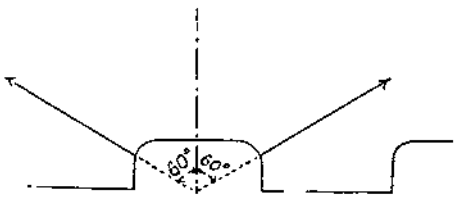


FIG. 3.—*Lines of Fire in Recess Trench.*

The time and labour required for the construction of these "nest" trenches is considerably less than in the case of ordinary or normal trenches, owing to the amount of earthwork saved by the ground untouched in the intervals (2 paces) between the "nests." This economy of time and labour is specially marked in the early stages of the work, when the cover afforded by the new form of trench advocated is very superior to that of the existing form of trench.

1. The regulation pattern trench for cover lying down, as distinguished from the individual rifle "pit" of similar dimensions, should be abolished. It takes nearly twice as long to construct as a "nest" in which men can fire sitting (a much more comfortable position); while the cover afforded (specially from shrapnel) is much less effective. Until it is completed to its full width the man's position is uncomfortable and exposed, and, even when finished, the man must lie on the damp earth.* Moreover, the lying-down position offers a large horizontal target exposed to shrapnel.

With a view to obviating this exposure of men lying down, by provision of better cover from view (though not from fire), a previous writer in the *Infenerni Jurnal* (May, 1910) proposed prizing up the turf (as shown in *Fig.* 4). Having some such course available the construction of a "nest" can be begun 1 pace in rear of it (*Fig.* 5) throwing the earth forward in such a way as not to spoil the raised turf. Each man (of the file) would dig in turn his own half of the "nest" while the other man lies down and fires, if necessary. The hole thus excavated would have a frontage of 2 paces (about 4′ 8″) with a diameter from front to rear of

* The writer considers that the prone or lying-down posi ion is not good for prolonged fire, owing to the discomfort of the rifle's "kick" on the man's collar-bone.

about 3′; allowing both men to sit or squat. The depth of the excavation will be such as to give a total height of cover of 21″ (*i.e.* cover for a man sitting); half of that amount (10½″) being excavated, and the other half in the breastwork (*Fig.* 6). The exposure to shrapnel is small, as the horizontal target presented by each man is only about 28″ square.

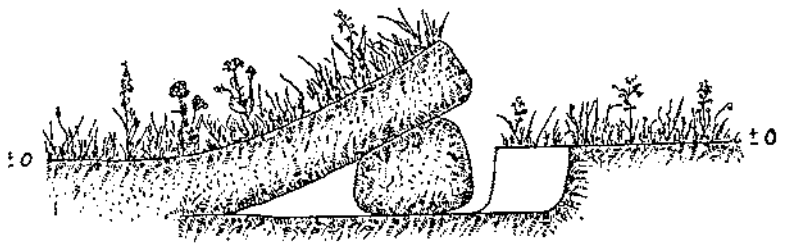


FIG. 4.—*Turf (or Sod) Cover.*

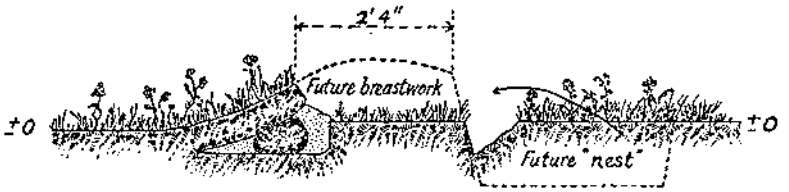
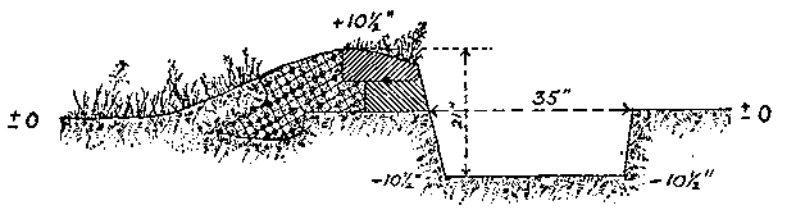


FIG. 5.—*The Beginning of a "Nest" Trench.*



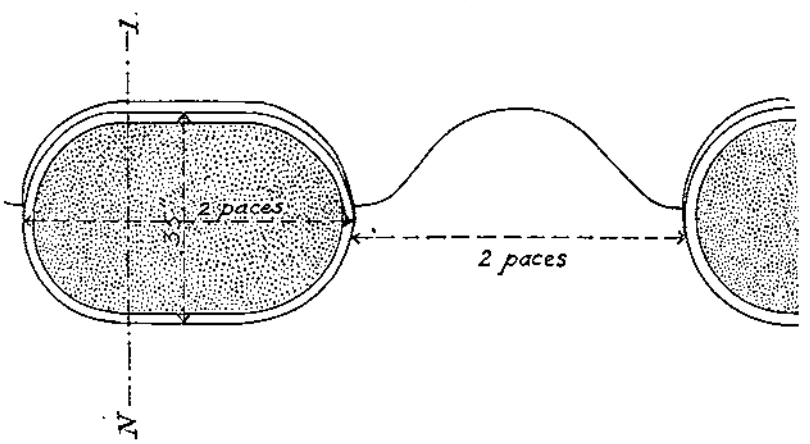


FIG. 6.—*"Nest" without Step.*

The amount of earth to be excavated by each man is only 4·06 cubic feet,* a task which in normal soil, with a small spade, could be finished in 13 minutes. In the case of the ordinary trench, cover lying down,

* The English equivalents of the author's figures are given, and they tend to show the tasks to be lighter than they probably would be.

the task amounts to (nearly) 5·1 cubic feet, or in the full-sized trench to 6·35 cubic feet; taking 16 to 20 minutes to complete. This advantage in favour of the "nest" form advocated is even greater than appears at first sight, owing to the fact that the area of hard surface soil to be dealt with, in the case of the regulation pattern trench, is nearly twice the size of that covered by the "nest."

2. Subsequent improvement of the "nest" trench consists in deepening the front part of the "nest" (by about 17½") to a total depth of 28", so as to provide room for the feet of the men sitting (*vide Fig.* 7).

Additional task per man	...	...	...	= 2½ cubic feet.*
„ time required	...	...	...	= 8 minutes.
Total time from commencement			...	= 21 „
„ earthwork	...	...	...	= 6·6 cubic feet.

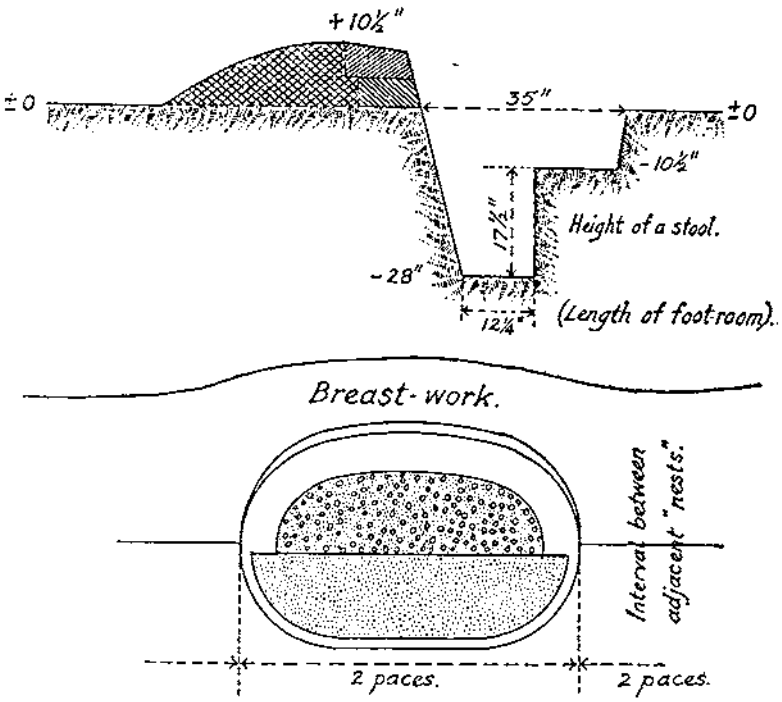


FIG. 7.—*"Nest" Sitting with Step.*

3. If time permits, it will be useful to add a trench in rear, for communication between adjacent "nests." This trench would be 28" wide and sunk level with the step or seat on which the men sit (*Fig.* 8).

This represents a task per man...	...	...	of nearly 7 cubic feet.
Time required ...	...	...	22 minutes.
Total time from commencement		...	43 „
„ earthwork „		...	13·6 cubic feet.

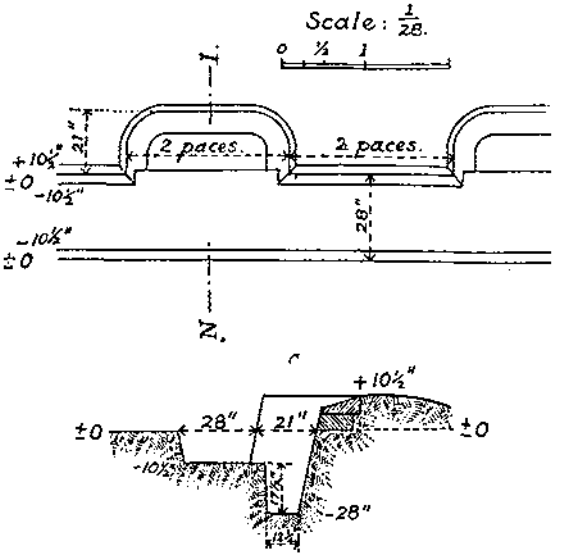
* The actual amount is nearly 3½ cubic feet.

Translator's Note.—It will be noticed that the tasks mentioned here are only (*approximately*) half the amounts given in the "Comparative Table" at the end.

This discrepancy is probably due to the fact that the amounts named here refer to each man's task on a frontage of 1 pace; whereas the table deals with a frontage of 2 paces.

The regulation trench for cover kneeling requires earthwork amounting to more than 24 cubic feet, or nearly double as much as the figures given above, to say nothing of the superior comfort and convenience of the sitting position as compared with kneeling.

The trench for communication might be widened later as time may offer, but this is a matter of secondary importance—the first consideration being cover for the men firing.



Section on N.I.

FIG. 8.—"*Nest*" *Sitting.*

4. The following further improvements would provide cover for men standing, with a small trench for communication purposes (*Fig.* 9).

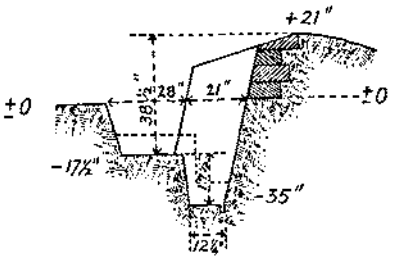


FIG. 9.—*Proposed Cover "Standing," with Small Communications.*

First, the bottom of the trench (on which the men's feet rest when sitting) would be sunk another 7" (to a total depth of 35") and the breastwork raised to a height of 21". Then the trench in rear (for communication) would also be deepened by 7"—to a distance of 38½" below the crest line of the parapet.

This represents an additional task of	...	8·64 cubic feet.
Which would be completed in ...	...	27 minutes.
Total earthwork from commencement	...	22·2 cubic feet.
,, time ,, ,,	...	1 hour 10 minutes.

Comparing the proposed form of cover thus improved, with the regulation trench for cover standing, we find that the earthwork of the latter amounts to 39·6 cubic feet, requiring at least two hours to complete.

5. Further improvement would be the work of a second relief, and would consist in deepening the communication trench down to the level on which the men stand when firing (*Fig.* 10 and the right-hand portion of the *Photo.*). Its clear width at bottom would be about 14″, which would be ample, as the firing line (in their recesses) would not block the way, as in the case of the ordinary trench.

This work represents a task of (nearly) ...	4·1 cubic feet.
Executed in	13 minutes.
Total time occupied in construction (1st and 2nd reliefs)	1 hour 23 minutes.

Thus it only takes 40 minutes to convert the cover "sitting on step" into really good cover standing.

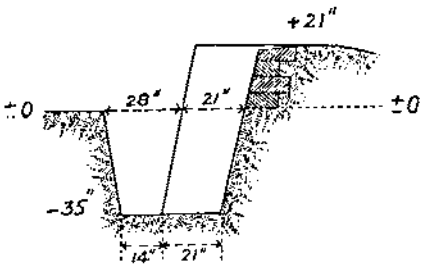


FIG. 10.

6. On the defensive, or at a distance from the enemy, when plenty of time is available, it would be possible to provide for additional comfort, and to deepen the communication trench to a depth of nearly 4′ 4″ or some 17½″ below the level on which the men stand when firing.

In this case the communication trench would be 14″ wide at the foot.

The amount of earthwork per man would be	68·1 cubic feet.
Requiring in normal soil with a small spade	3½ hours.
Or with a large spade	2 hours 40 minutes.

In the ordinary type of trench giving cover standing, the earthwork amounts to more than 90½ cubic feet, which would take 4¾ hours to complete with a small spade or 3 hours, 33 minutes with a large one.

It will be seen from what has been said above, that at every stage of its construction the "nest" form of cover advocated represents a substantial saving of labour and time.

7. In the *Photo.* the legs of men sitting in one of the recesses are seen exposed, though the men themselves are under cover from shrapnel fire. This can be easily obviated by narrowing the ledge (on which the man is sitting) to a width of 14″—which is quite sufficient. The soldier's legs would then be entirely within the "nest" or recess. The earthwork would only amount to 1½ cubic feet, and could be done in 5 minutes—or at any time, bit by bit.

No traverses are necessary to give cover to the firing line from enfilade fire, though the communication trench would have to be defiladed, either by means of traverses, or by its trace* (*Fig.* 11).

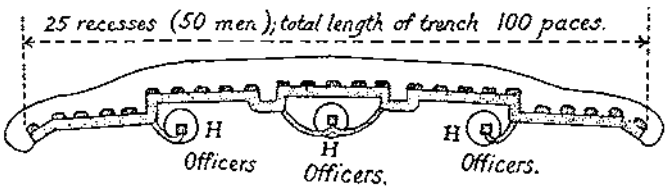


FIG. 11.

Similar "nests" should be constructed for officers, some 4—7 paces in rear of the firing line and connected therewith by small communication trenches (see *Fig.* 11—H.H.H.).

The annexed comparative table shows the amount of time and labour required for the successive stages in the construction of the various forms of cover referred to above. The same conditions have been assumed in all cases, viz.:—a frontage of 2 paces per man, average soil, and a small spade.

The last column, "saving of labour" has been worked out from the minimum amounts of labour required for the type of cover referred to.

It is important to notice the great saving of labour at the initial stages of the work. The types of work to which most importance is attached are Nos. 3 and 6, of which the first is specially suited for use in the attack, and the second for employment on the defensive. Nos. 4 and 5 are intermediate forms suitable for the hasty entrenchment and defence of a position.

The times given in the table, can only be approximate, owing to varying conditions of soil, etc., but they will suffice for purposes of comparison.

In conclusion it is urged that the proposed form of cover is greatly superior to the ordinary type of fire trench, and is more in accordance with the requirements of modern fighting.

* Attention is also drawn to the small modification shown in the profile of the superior slope of the parapet. It is claimed that the small inward slope or curve suggested, adds to the comfort and convenience of firing over the breastwork.

COMPARATIVE TABLE.

Trenches of Normal Regulation Type.			"Nest" or Recess Trench Advocated.			Saving of Labour in the "Nest" Type Advocated. % ‡
Stage of Construction.	Earthwork, Cubic Feet.	Time taken in Construction.	Stage of Construction.	Earthwork, Cubic Feet.	Time taken in Construction.	
1. Individual rifle pit (cover lying down).	5·08 cubic feet (+ superfluous turf).	16 minutes* (or more).	1. Separate "nests" (cover squatting without step) (*Fig.* 6).	4·06 cubic feet.	13 minutes.	25% (or more).‡
2. Trench (cover lying down).	9·5 cubic feet.	30 minutes.†	2. "Nest" (cover sitting on step) (*Fig.* 7).	6·6 ,, ,,	21 ,,	43%
Trench improved (widened).	12·7 ,, ,,	40 ,,	—	—	—	90%
3. Trench (cover kneeling).....	24·1 ,, ,,	1 hour 16 minutes.	3. Line of "nests" (cover sitting on step) (*Fig.* 8).	13·6 cubic feet.	43 minutes.	78%
4. Trench (cover standing) (*Fig.* 1).	39·6 ,, ,,	2 hours 5 minutes.	4. Line of "nests" (cover standing, with small communication trench) (*Fig.* 9).	22·2 ,, ,,	1 hour 10 minutes.	78%
5. Trench (cover standing) (*Fig.* 1).	39·6 ,, ,,	,, ,,	5. Line of "nests" (cover standing) (*Fig.* 10).	26·3 ,, ,,	1 hour 23 minutes.	50%
6. Trench (cover standing on step).	90·5 ,, ,,	4 hours 45 minutes.	6. Line of "nests" (cover standing on step) (*Photo* 1).	68·1 ,, ,,	3½ hours.	33%
			7. Line of "nests" (cover standing, with seat under cover from enfilade fire).	69·6 ,, ,,	3 hours 35 minutes.	30%

Remarks:—

1. * The actual size of this type of rifle pit must depend upon the size of the man.
2. † The larger expanse of hard dried surface soil (or turf) to be dealt with in the case of the normal type of trench, causes delay and so favours the other form of trench advocated.

‡ *Translator's Note.*—These are the author's estimates.

SAND-BAGS AND THEIR APPLICATION DURING THE RUSSO-JAPANESE WAR.

Extracts from an article by Z.M., published in the June-July number of *Injenerni Jurnal*.

The war showed the extreme value of sand-bags, both in attack and defence, in field and siege warfare. On certain occasions they were an absolute necessity, as, for instance, when it was required to make cover under the heavy rifle fire of the enemy, or on rocky or frost-bound ground, or inside the concrete galleries of permanent works, or when revetting loose stone parapets in a land where no other revetting material was available.

In Field Warfare in the Attack.

The Japanese were the first to make wide use of sand-bags under these conditions.

A Japanese officer writes as follows:—"The bags used were rectangular, of a light cotton material, khaki colour, about 21″ long by 9″ wide. During the march they were carried, rolled up, either in the knapsack or cartridge bag. As soon as the men arrived within the sphere of hostile rifle fire they filled the bags with grass, hay, light twigs, earth, sand, stones, etc., and used them, when firing in the lying position, as cover from fire and also from view. During the advance they were best carried slung over the left shoulder, and when they were no longer required they were thrown away. For filling the bags, even in a cramped position, only 1 to 2½ minutes were required, if material was easily available, but if it was necessary to excavate in stony or frozen ground more time was wanted. When using sand-bags, the accuracy of shooting was improved, as the rifleman, feeling that he was behind cover and that he presented considerably less of a mark to the enemy, gained confidence and calmness from the feeling of greater safety. In stony or frozen ground where the shovel could not be used, these bags, filled with earth or sand, were used for constructing cover. When the troops were not in action but on the march or in bivouac, the sand-bags, filled with straw and weighing 2½ to 3 lbs., were used as pillows, or, without the straw, for carrying small articles of equipment, or as a protection against flies and mosquitoes."

These sand-bags, when filled with earth, weighed between 30 and 40 lbs., and, for greater convenience in carrying, were fitted with handles.

In the series of battles which took place before Mukden in February and March, 1905, many examples occurred of the use of these sand-bags in action. Thus on one occasion the Japanese 5th Division, in order to cross over a zone swept by the enemy's rifle and machine-gun fire, constructed no less than eight separate lines of trenches arranged for firing, standing and kneeling. These were all made in the course of 72 hours and were sited respectively at 1,500, 1,200, 800, 500, 400, 300, 200 and 100 paces from Russian position, and from 800 paces onwards they were made almost entirely of sand-bags, as the frozen state of the ground allowed of very little excavation.

In the operations of Oku's army further to the west, parties of infantry carried with them sand-bags already filled with earth. This they were enabled to do by having their equipment carried by hired coolies. On arriving at dawn within 1,000 paces of the Russian firing line, they lay down behind a breastwork of the bags, and after a short artillery preparation began to move gradually forward rolling the filled sand-bags before them, there being no prospect of filling them again owing to the frozen state of the ground. When they had arrived within 600 to 700 paces from the position they stopped, and threw up a continuous line of new trench, made of sand-bags protected on the outside with clods of frozen earth. In the following night under cover of darkness, having made a fresh breastwork within 300 to 400 paces of the Russians, they carried out a series of desperate attacks, all of which were beaten back from the wire entanglements. In spite of these failures they were enabled by their sand-bag breastworks to remain for two whole days in the closest proximity to the Russian lines under very heavy rifle and machine-gun fire.

Both of these examples occurred on the west side of the railway where the ground was level. In the hilly region lying to the east, sand-bags were little used, probably because the ground was covered with trees and bushes and intersected with ravines and precipices, all affording a plentiful supply of natural cover.

There were not many opportunities for the Russians to practise the use of sand-bags in the attack, but a few cases did occur. For instance, on the 1st March, 1905, in this same neighbourhood on the west of the railway, parties of the 3rd and 7th Rifle Regiments, after capturing a position, spent two whole nights in entrenching it, and here they built up the inner slopes of their parapets with sand-bags, making loopholes and, later on, even traverses. In all, trenches for two double companies and an approach 200 paces in length were constructed, and 5,000 bags were used, which were carried filled over half a verst to the position.

But the use of sand-bags in the attack is not limited to frost-bound ground and wintry conditions. When filled with earth and laid in several rows they will stop rifle bullets; when filled with grass or twigs they may afford concealment, which is protection against all kinds of fire; and by giving confidence to the men, besides rests for their rifles, they will increase

the accuracy of their fire and reduce their losses. There are however certain objections attached to their use. Weighing about 35 lbs., they cannot be carried in addition to other equipment, and if this is left behind it may cause serious inconvenience in case of an unexpected pursuit or of a retirement not exactly over the original line of advance. Again, a single row may stop shrapnel bullets, but will not stop rifle bullets. For these three or four rows (2½′ to 3′ thickness of parapet) are required, so that to cover one man it is necessary to use the sand-bags of two or three others, who are thus left without protection.

Sand-Bags in Field Warfare in Defence.

On both sides the use of sand-bags was far greater in defence than in the attack. They were used for revetting slopes, making loopholes and traverses in works and trenches, and also for repairing damage caused to parapets by the explosion of common and high-explosive shells.

In the mountainous parts of Manchuria, where the ground was generally stony and often solid rock, the parapets had to be built up of fine or coarse stone rubbish, covered with a layer of carried earth. All the revetments, loopholes and traverses were made of sand-bags, the material used being the cheap American cotton fabrics of grey and other colours which were commonly worn by the Chinese.

The repairing of the so-called Railway Redoubt during the Mukden fighting is a good example of what can be done in the way of repairs to fieldworks with the help of sand-bags. Here after 1½ hours bombardment by 6″, 8″ and even 11″ artillery, all the casemates were demolished and the parapets half levelled. On the approach of night when the Japanese attacks and bombardment were discontinued, the Russians set about repairing the damage. Owing to the frozen state of the ground and the limited time available, entrenching tools were considered to be of little use and it was decided to use some sand-bags which happened to be available in store. By the efforts of two companies 500 sand-bags were carried up to the redoubt, and with these it was possible to repair the main parapet.

Use of Sand-Bags by the Attack in Siege Warfare.

In the Kwantung peninsula where rocky ground prevailed not only in the hills but also frequently in the plains, both opponents found it necessary, when working within the sphere of the enemy's shrapnel and rifle fire, to save time and labour by making breastworks of sand-bags rather than deep trenches. These they protected on the outer side by stone rubbish covered with a layer of clay. In the provisional works which were made in the presence of the enemy, but beyond the range of his artillery fire, sand-bags were also freely used for revetting slopes, owing to the absence of timber or other suitable revetting materials in the neighbourhood of Port Arthur.

The Japanese used sand-bags in their regular saps, and also in the assault, for securing the possession of important captures, or for keeping a footing on a position where the main object had not been obtained. Their saps were pushed forward under the cover of sand-bags, barrels filled with earth, sap-shields, etc. All the parapets were crowned by high *bonnets* of sand-bags, with narrow embrasures between them, masked by curtains of khaki material. In rocky ground the parapets were built up entirely of sand-bags. In the approaches to Fort No. III. they made use of an original method of protecting themselves from the fire directed upon them from the Russian advanced positions further to the south, by making a double series of sand-bag traverses, parallel to the front, each 6′ to 7′ in height and 21′ to 28′ in length, breaking joint, and spaced at 21′ to 28′ from one another.

During the assaults on 203-Metre Hill they succeeded on one occasion in reaching at dawn the outwork which crowned the crest, but could get no further owing to the heavy fire directed upon them. As they lay exhausted on the bare slope they set to work to construct a breastwork of sand-bags which they had brought with them, and in spite of heavy losses they succeeded in completing it and connecting it with their nearest trenches, and thus obtained a *point d'appui* for further assaults. This they also did on the neighbouring 211-Metre Hill, when they had got a footing on its eastern crest. On Flat Hill they made their approaches like blinded saps with both parapets of sand-bags.

In August, when they obtained possession of the two redoubts which were situated between Forts Nos. II. and III., they adapted the interior areas of these works for protection against fire from all directions. For this purpose they built up breastworks of sand-bags and roofed them over with beams and sand-bags.

During the period of the mining warfare they used sand-bags for carrying earth from the mine galleries, for constructing obstructions when crossing the counterscarp galleries, and for the blinded saps across the bottom of the ditch.

The best example occurred in Fort No. II., where after penetrating into the counterscarp gallery they crossed it under cover of a breastwork of sand-bags, and then cut their way through the outer wall into the fortress ditch. After this, during the night, they made a covered sap across the ditch with sand-bags and joists, proof against rifle and machine-gun fire from the flanking galleries on both sides, but which however was speedily demolished by the defenders with gun fire.

In the fighting in the counterscarp gallery of this same fort the defenders put up a series of cross-walls of sand-bags for its protection. In attacking these the Japanese made a kind of movable parapet of three rows of sand-bags, in height about 4′ 8″, which they worked forward by throwing the bags in the nearest row over to the far side of the others.

Use of Sand-bags in Siege Warfare by the Defenders.

The stony nature of the soil around Port Arthur compelled the use of sand-bags in most of the fortifications. They were used in the outlying covering positions, in the defence of localities and in the temporary works, which lay within the fortress zone, and finally in the permanent works themselves, for revetments, traverses, the roofing of casemates, and sometimes in the construction of complete parapets. Both small sand-bags and also sacks from the supply stores were used for these purposes.

In the preparatory period when the fortress works were being hastily completed, sacks filled with broken stone were used instead of brick and stone in revetments. In Work No. 3, the exit from the casemated barracks into the gorge ditch was protected in this way, and also a structure which took the place of an armoured conning tower. The ramparts of some not fully completed forts and batteries, and traverses separating guns, were built up of sand-bags filled with earth. Two dilapidated Chinese *impans*, or serais, lying between Forts Nos. II. and III. were put in a state of defence by having the interior slopes of their parapets revetted with barrels and sacks of earth.

On 203-Metre Hill a great many blindages were made in the deep trenches on the summit and on the reverse slope, and were covered with beams, rails, stone rubbish and sand-bags. Many of the latter were made out of old great-coats.

During the final assaults on the permanent works, it was found necessary to provide the men manning the front parapets with shrapnel-proof cover, and this was done by building short lengths of sand-bag walling along the rear edge of the banquettes, with a roofing of thick planks held down by sand-bags on their front and rear ends.

In rear of the Chinese Wall there was a series of dug-outs and blindages, the roofs of which, and in many cases the walls also, were made of beams covered with stone rubbish and sand-bags.

In the defence, as in the attack, the works carried out under the immediate fire of the enemy could not have been done at all without the help of sand-bags. Examples of their use occurred during the preparations for the re-capture of the redoubts between Forts Nos. II. and III., and here also the communication trenches were protected, after the example set by the Japanese, by a double row of traverses placed parallel to the front, 6′ to 8′ in height, 14′ to 28′ in length, breaking joint, and 21′ to 35′ apart.

The use which was made of sand-bags in the defence of the counterscarp galleries has been already described; the successive walls were placed at 21′ intervals. Flanking protection for the ditches on the flanks of Fort No. II. was built of sand-bags, and the interior area of the same fort was broken up into sections of defence by the same means.

As material for sand-bags, it was found that cotton, hemp, flax or woollen materials were in considerable danger of catching fire, and that their use in places where water was not available was dangerous. The chief causes of fire were common shell and certain special contrivances practised by both combatants. The abandonment of Redoubt No. 1 is attributed to the blindages and sand-bags having caught fire under a heavy bombardment, and in the defence of Fort No. II. the Russians sprayed kerosene by means of a fire engine on the sand-bag crowning of the Japanese saps, and set it on fire by specially prepared fuzes, with the result that the parapet fell to pieces.

F. E. G. SKEY.

NOTICE OF MAGAZINE.

RIVISTA DI ARTIGLIERIA E GENIO.

October, 1911.

MILITARY WIRELESS TELEGRAPHY.—An article on the above subject by Capt. Bardeloni of the Engineers in the October number, contains matter of much interest.

The employment of wireless telegraphy in naval warfare, as a unique means of communication at great distances between the various units and for regulating the action of troops on land, is of the greatest importance for military operations. Neither the mountains, the mist, nor any other obstacle prevents the use of wireless telegraphy when it is desired to communicate orders or notices to others or to call for reinforcements, and in field operations, either in the plains or mountains, in sieges, or in reconnaissances, wireless telegraphy is a most useful auxiliary not in any danger from the breaking of telegraph wires. But there is more. To-day not only are reconnaissances made by divisions and detachments on the march towards the enemy, but also with the assistance of balloons, dirigibles and aeroplanes.

The author goes on to define the various means of applying the science of wireless telegraphy to military requirements.

Field Stations.—It will be more than ever desirable on the battlefield that wireless telegraphy should be used as a means of communication between the masses of operating troops and the commands on which they depend, thus safeguarding probable interruptions such as the breaking of telegraph posts and wires. It should also be possible to make use of wireless telegraphy in regions of not too great an extent, with suitable receiving and transmitting instruments.

Now, where wireless telegraphy may be of practical use is in the reconnaissances made by the exploring cavalry. What should be the characteristics of the field stations and of those for cavalry? For both cases there should be complete wireless telegraph apparatus adapted to send messages of about 100 kilometres over every kind of ground, be it mountainous or woody.

The weight of the apparatus, compatible with the energy required for the stations, should be reduced to a minimum; the system of transmission and receiving would naturally be such as to insure as far as possible the syntonization of the circuits, permitting of the generation of two or three lengths of waves, differing sufficiently from one another and to be employed indifferently according to circumstances. The mobility of the stations is of importance in both cases. For the field stations it is only

necessary that they should be able to follow the troops and the commands, and the various materials can be carried on a small carriage with trained animals, great rapidity of movement not being required; but for the stations for cavalry greater speed would be necessary.

The author goes on to recommend the use of automobiles, as the apparatus would work more usefully in the closed carriage of an automobile, than in the open. Automobiles for the stations of advanced reconnaissances are stated to have been tried with the best results, in the French manœuvres of 1909, and they have also been adopted in Germany.

Permanent Stations.—What has been said with regard to the application of wireless telegraphy to field stations is also applicable for the defences of fortified places. But the limitations are less in this case, partly owing to less disturbances in the air, and partly to diminution in the dimensions and weight of the machinery. In places where the house of the Consul is situated in a suitable locality, there would be advantages in syntonization and dirigibility so as to secure good communication with other stations, both permanent and field, which have to correspond with the place.

Wireless Telegraphy from Dirigibles and Aeroplanes.—Evidently this problem requires certain special arrangements. As is well known it is usual to communicate through the air either through earth, or through the sea, so as to make an earth as it is called, but this is not possible in a complex apparatus existing entirely in the air. Hertz has demonstrated practically the truth of Maxwell's theory that the propagation of electromagnetic oscillations happened equally if the oscillation did not communicate with the ground. Again to-day, in practical wireless telegraphy, there are discussions on the function that the earth has in the propagation of the waves, but in some cases they have fortunately succeeded in transmitting, with good results, wireless messages, although substituting for the contact with the earth one or more metallic conductors isolated from the earth, and having electric characteristics equal to those of the wire or complex wires which constitute accessories of the aerial line. The aerial is therefore said to have its *counterpoise*, and it will be necessary to recur to the system of counterpoises to adapt wireless telegraphy to dirigibles, by forming the irradiating apparatus of a long wire of 100 to 200 m. wound ordinarily around a small drum.

E. T. THACKERAY.

CORRESPONDENCE.

TACTICAL RECONNAISSANCE.

SIR,

In the December number of the *Journal* (only lately received in this distant station) is printed a reconnaissance report made by two young officers of the Corps. In view of the high praise bestowed upon it in the covering letter, it may seem presumptuous to offer any criticism; but, although the substance of the report is without doubt excellent, the form in which it is rendered appears to violate principles which are deemed to be, by some authorities, of great importance. The subject being one of considerable interest to R.E. officers, it appears permissible under the circumstances to call attention to these principles.

To start with reconnaissance in general, the first consideration is time. Were time available the G.O.C. would probably prefer to judge everything for himself on the spot. This being impossible he employs officers of his staff or of units to judge for him. The General Staff will be receiving many reports on divers subjects, and to save their time is a very important matter. This can surely best be done by *starting every report with a précis of the information obtained.* It can then be seen at a glance whether a certain route is practicable or not, which of several apparently convenient bridging sites is to be preferred, and so forth.

Provided that it is known that the judgment of the officer who has made the report is to be trusted, the *details* can be left for later consideration. When, after examining the *précis* of reports on alternative routes, etc., it is decided to make use of any particular one, the detailed information in that report must be distributed to those immediately concerned. To again save time, it is obviously desirable that *all information on any one subject should be grouped together under an appropriate heading, which should be clearly indicated by underlining or placing in the margin.* This sorting of information into headings will only mean a very slight extra trouble and loss of time to the officer carrying out the reconnaissance, but will result in a very great saving of time and trouble to everyone else who may have to extract the information from the report.

The second important consideration is for the officer carrying out the reconnaissance to be continually, in imagination, placing himself in the position of the officer who has ordered the reconnaissance and of those whom the details of the report will affect. It will then be easier to give the information acquired in the most useful form.

To come now to the particular case under consideration. Owing to the scheme being apparently part of a larger scheme known to the

officers on the tour, it does not give much information, and some of the following suggestions may thus, unavoidably, be not actually applicable: *e.g.* there may have been no heavy artillery on the right of the position, although this arm is mentioned in the printed report.

From the scheme as given, however, it would appear that the order for the reconnaissance was issued by the O.C. 55th (Field) Company, R.E., under the direction of the General Staff—the object of the latter being to discover if this road was practicable for artillery in retreat, and that of the former to ascertain how the road could be improved by one section of his company. The officers interested in the details will be the G.S., the O.C. R.A., the O.C. Field Company, R.E., and the O.C. Covering Force.

The *précis* might then take somewhat the following form :—

1. The road from Portinscale to Buttermere is impassable for heavy artillery, and only practicable at a slow rate for field and howitzer artillery, there being several very steep slopes where the ordinary teams would require assistance.

2. The road is screened from the enemy's view except for some 400 yards S.W. of Stair (A5).

3. To protect the retreat on this road a force, strength about ... (M.I. recommended if available) posted about Cat Bells (C6) should be sufficient.

4. The road could be materially improved by one section Field Company, R.E, in ... hours. Materials available locally.

The detailed information would then follow, grouped under such headings as watering places, halting places, side tracks or passing places, covering force (giving strength, position, and lines of retreat), width of road, surface, bridges, bad gradients involving assistance to the teams, giving exact site (so that if necessary operation orders may order increased distances between batteries, etc., to avoid blocks on the retreat), improvements proposed, giving order of importance; sites, details and time required. And so forth.

It certainly seems to me that a report in the above form will, to a General Staff working at high pressure, more nearly fulfil the requirements laid down in *F.S. Regs.*, Part I. (1909), para. 9, sub-para. 2, than would a "Road-Book" style of the report if handed in.

Yours faithfully,

B. BORRADAILE,
Capt., R.E.

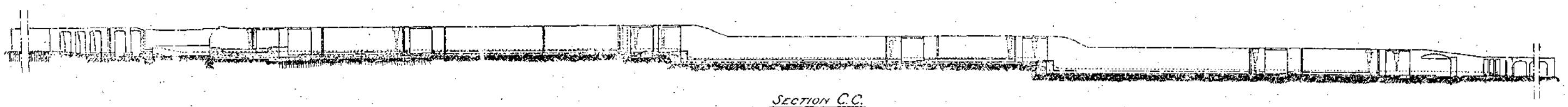
Tientsin, 27. 1. 12.

The Editor, *R.E. Journal.*

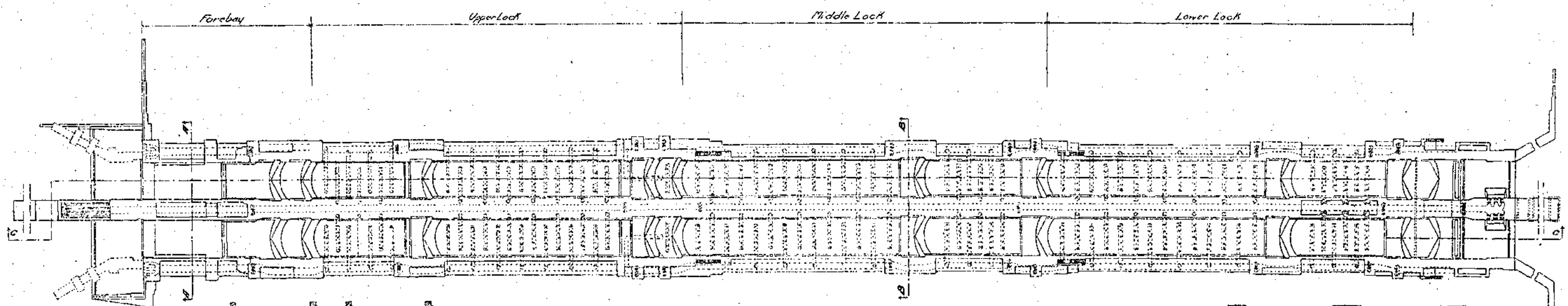
NOTES ON THE PANAMA CANAL.

GATUN LOCKS.
Scale 1" = 200'

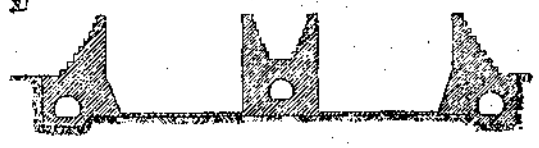
FIG. 3.



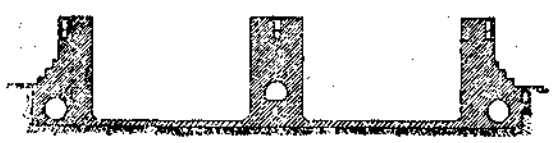
SECTION C.C.



PLAN

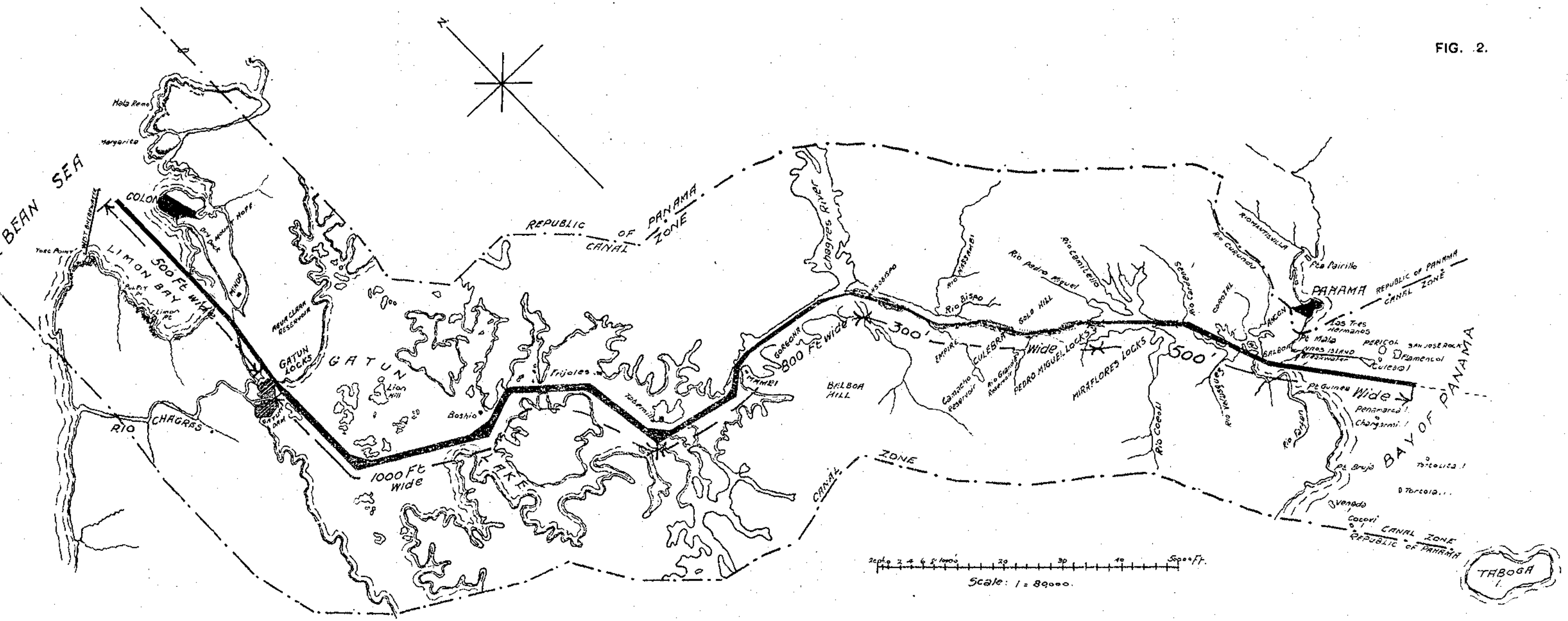


SECTION A.A.



SECTION B.B.

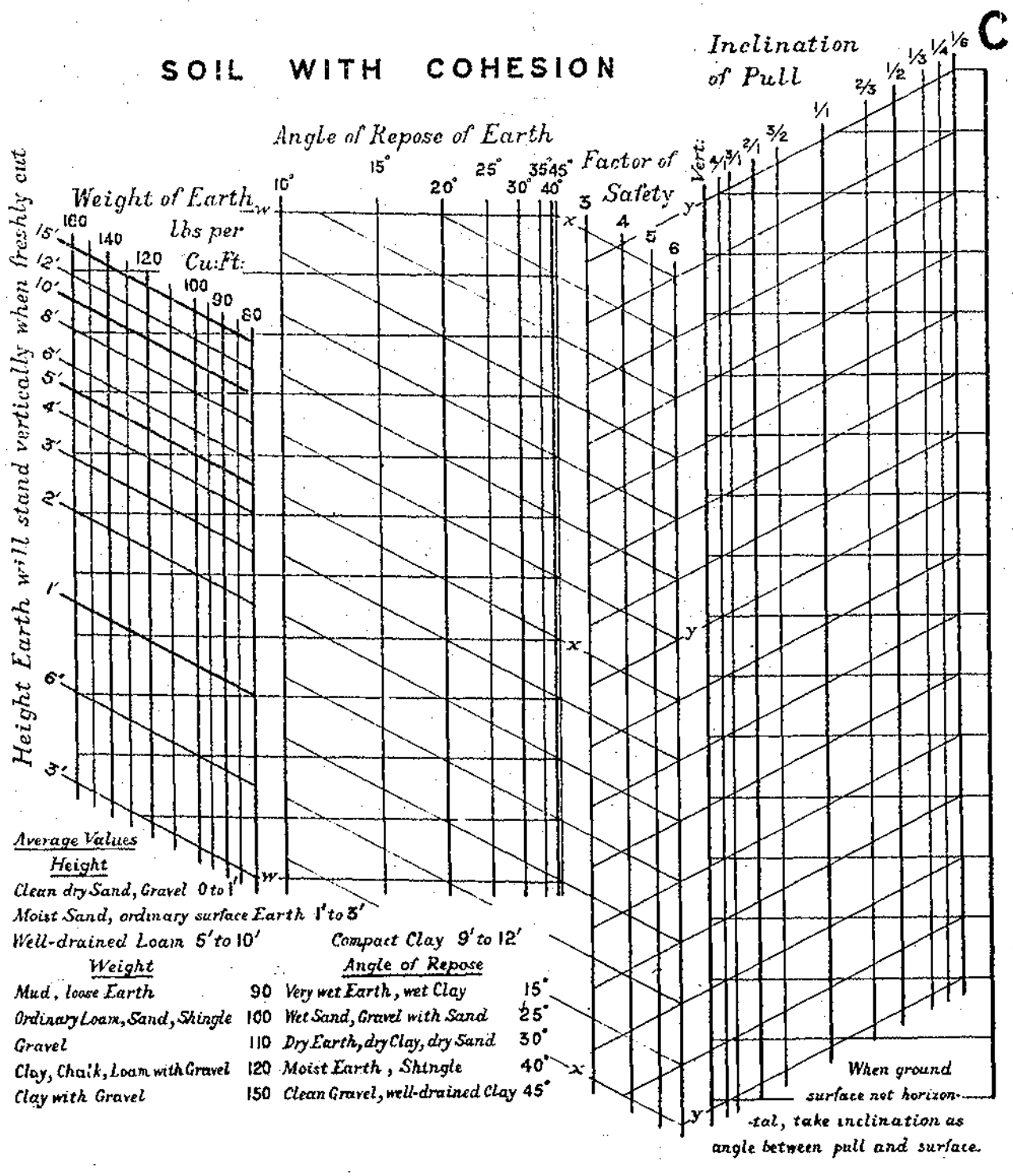
FIG. 2.



MAP SHOWING CHANNEL OF THE PANAMA CANAL.

SAFE RESISTANCE

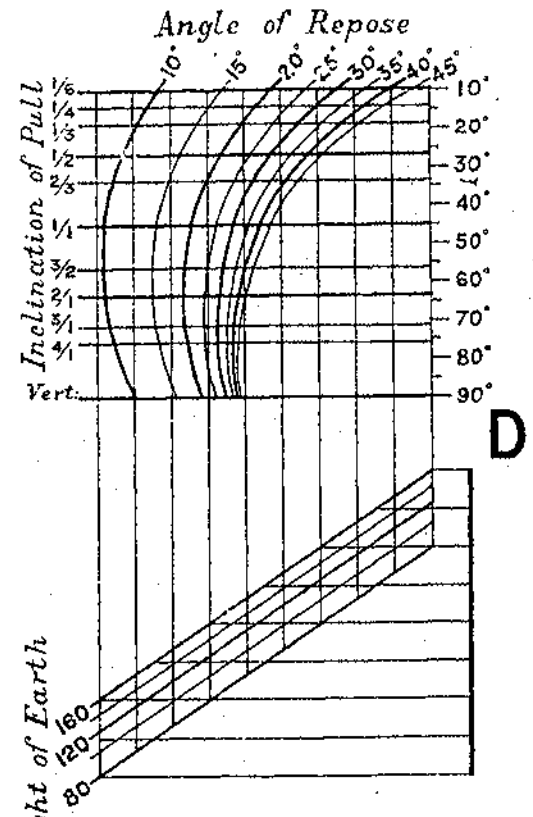
SOIL WITH COHESION

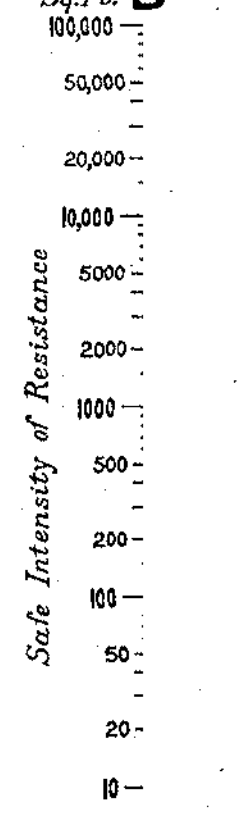


Average Values

Height		Weight		Angle of Repose	
Clean dry Sand, Gravel	0 to 1'	Mud, loose Earth	90	Very wet Earth, wet Clay	15°
Moist Sand, ordinary surface Earth	1' to 3'	Ordinary Loam, Sand, Shingle	100	Wet Sand, Gravel with Sand	25°
Well-drained Loam	5' to 10'	Gravel	110	Dry Earth, dry Clay, dry Sand	30°
Compact Clay	9' to 12'	Clay, Chalk, Loam with Gravel	120	Moist Earth, Shingle	40°
		Clay with Gravel	150	Clean Gravel, well-drained Clay	45°

SOIL WITHOUT COHESION





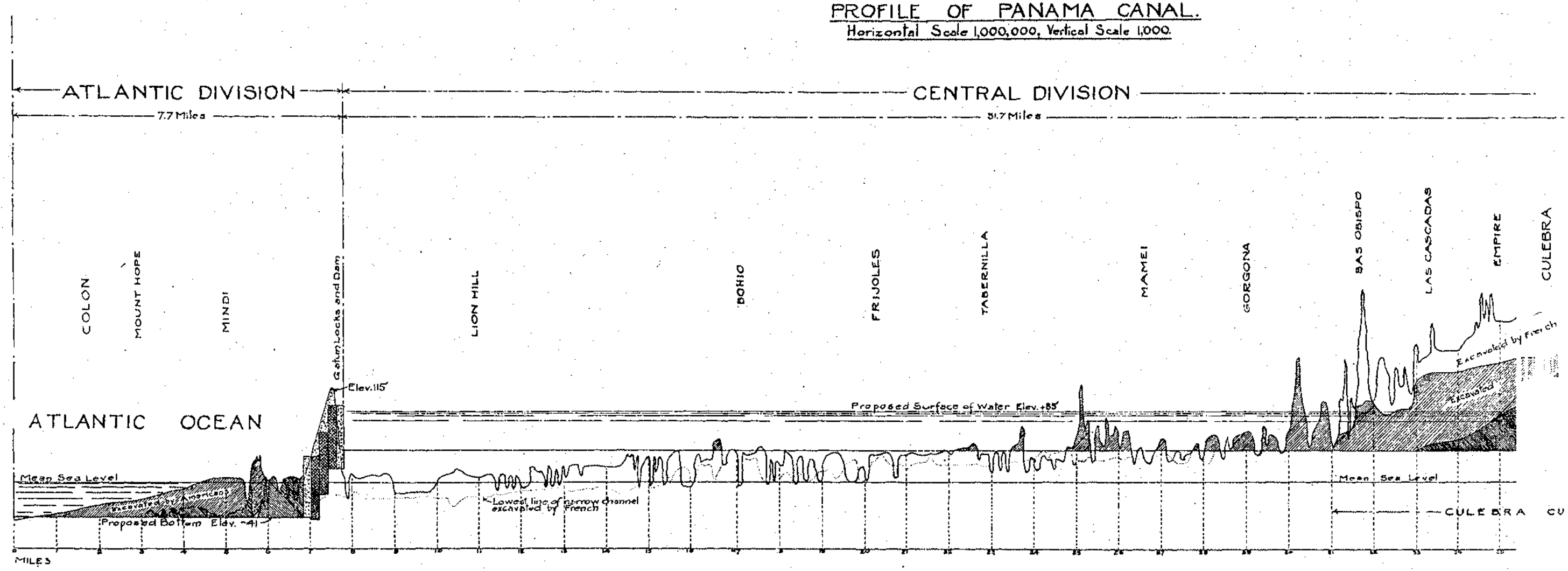
For Soil with Cohesion, enter chart by lines representing height soil will stand vertically till vertical rep: weight is met; from intersection proceed parallel to lines w till vert: rep: angle of repose is met; from inter: proceed par: to lines x till vert: rep: factor of safety is met; from inter: proceed par: to lines y till vert: rep: inclination of pull is met; from inter: proceed horizontally to Scale C. Join this point mean depth of anchor beam; this will give safe intensity of resistance point till vert: rep: breadth of anchor beam is met; from inter: proceed met; from inter: proceed horizontally to scale rep: total safe stress in For Soil without Cohesion, such as shingle, enter by curved lines rep: a of pull is met; from inter: proceed vertically till inclined lines rep: we Scale D horizontally; from this point proceed as before.

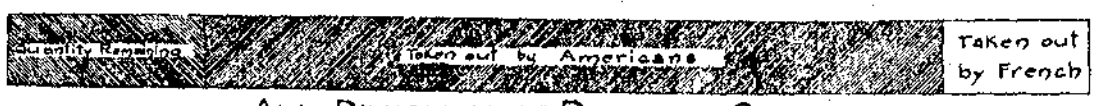
For accuracy it is advisable to find the various intersections by r

NOTES ON THE PANAMA CANAL.

PROFILE OF PANAMA CANAL.

Horizontal Scale 1,000,000, Vertical Scale 1,000.





ALL DIVISIONS OF PANAMA CANAL