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NOTES ON ROYAL ENGINEER WORK AT SIERRA LEONE, WEST COAST OF AFRICA, 1911–13.

ALMOST all the work is in, and around, Freetown, but there are three stations in the Protectorate, namely Port Lokko about 40 miles by launch from Freetown, Mabanta 23 miles north of Port Lokko, and Wankifu 18 miles north of Mabanta.

Freetown, the chief town of the Colony, is surrounded by a semi-circle of hills—the remains of the crater of an extinct volcano having a diameter of about 4 or 5 miles with Freetown as its centre.

Tower Hill is a conical hill nearly 400 ft. high, clear of bush and about 3½ miles east of the sea.

Mount Aureol is about 1½ miles east of Tower Hill, 800 ft. high, and extends towards Kortright Hill, 1,000 ft. high.

Wilberforce is 2½ miles south-west of Tower Hill—600 ft. high. A light railway runs from Freetown to Wilberforce (Hill Station) but the trains are infrequent, inconvenient, and slow. Generally, to get to Wilberforce from Mount Aureol one has to descend 700 ft. and rise 500 ft. in a distance of about 5 miles by road.

King Tom is about 1½ miles north-west of Tower Hill on a small cape.

Personnel.—The O.C.R.E. is generally a Major and has the ordinary C.R.E.'s power. The G.O.C. is also M.G.A. of the Company Officers; the C.O. is generally D.O. Tower Hill. The O. i/c E.L. has the East or Mount Aureol Division, and is O. i/c R.E. Stores and commands the Right (European) Half-Company. The other subaltern commands the Left (Native) Half-Company and is D.O. West (Wilberforce) and 1st Line Defences.

The Staff for R.E. Services include :—

At Head Quarters.—An A.I.W. generally a S.M. F. of Works, 1 engineer clerk, 2 draughtsmen, 1 storekeeper, 1 ledgerkeeper, 1 mechanist machinery, 1 mechanist electrician, 1 mechanist telephonist. There are 5 foremen of works, usually distributed as under :—1 Tower Hill, 1 Mount Aureol, 2 Wilberforce, 1 Protectorate. The two at Wilberforce are necessary on account of the distance, but one acts as a reserve in the event of sickness among the others.

Soil.—The soil consists entirely of syenite slabs and boulders, and laterite rock and earth ; the boulders are always found surrounded by laterite, and it is rare that an excavation of any extent can be made in laterite soil without coming on large syenite boulders weighing many tons. Extreme care should be taken in estimating

for excavation, for it is impossible to foretell with any accuracy the amount of syenite lying below ground. It is often practically a solid mass of igneous rock.

The rocks can be bored and blasted, but even then are generally in such large lumps that they cannot be moved; they are further split up by building a wood fire on top and throwing water over them when hot.

Water.—The soil is porous and the laterite acts as a natural reservoir or sponge, being refilled each rainy season and delivering up its yield gradually during the remainder of the year. Until March most of the water courses have a good flow of water, during April the flow diminishes gradually, and during May and until the tornadoes arrive in June the supply from the surface is decidedly scanty.

Owing to the porosity of the soil and the steep faces of the slopes, impoundage is practically impossible, and the system adopted is to place quite small dams at various likely positions (for choice close to a bit of impermeable rock) and to bring the water direct by pipe to storage reservoir close to the town.

For W.D. supplies there are three systems, each with a reserved collecting area closed to the troops and the public.

These are :—

(1). Tower Hill Supply—in the White Water Ravine. The supply here has recently been considerably augmented by boring.

(2). For Mount Aureol and Kortright, in the Gloucester Collecting Area. The method of collection has recently been improved and the supply considerably augmented—more can probably be done in this connection.

(3). The Wilberforce Supply—from the Regent Collecting Area. This supply is very scanty after April and boring should be made close to the dam to supplement the amount. (In cases where borings are used to tap the natural reservoirs care should be taken that they should not be drawn upon except when the need actually exists, otherwise there is a chance of the reservoirs being prematurely exhausted).

Building Materials.—The syenite is extremely close grained and hard. At Hill Station it appears harder than at Mount Aureol. It has been used for building in ashlar and rubble, but is very hard to dress and is more usually used now as the aggregate for concrete and concrete blocks.

The laterite is soft and can be easily cut into blocks for building. It weathers hard but always remains somewhat porous. It is also used for aggregate, and does well where no excessive weight is likely

to be put on it ; as a rule weathered laterite should be used as it is harder ; the ordinary rock if broken up crumbles somewhat and needs sifting and cleaning. The syenite is very costly to break up for concrete.

Sand is obtained from the seashore. It costs practically nothing to collect, but as it has to be transported distances varying from 2 to 4 miles and sometimes to 1,000 ft. above sea level, the transport charges are enormous. There is no limestone in the country. All lime has to be imported from the United Kingdom.

There is good local timber to be obtained, but it has to be brought from such a long distance that the cost is excessive and recourse is had to the United Kingdom instead. Small quantities of scantlings of fir and deal can be obtained locally, also weather boarding and match boarding.

For native huts the best poles procurable are mangrove and monkey apple—both very heavy and not attractive to white ants and " bug-a-bug " (a boring insect). They are excessively dear, *i.e.* 8s. to 12s. a dozen, if bought from local purveyor, but can be obtained for 2s. to 3s. per dozen if cut in W.D. reserved catchment areas and brought in by the troops on working pay.

There are no local manufactures and not much in the way of local purchases. Almost all stores of steel, iron and small material have to be procured from the United Kingdom on indent. Small quantities of corrugated-iron sheets can be obtained locally, but it is rarely of thicker gauge than 26 S.W.G. A few small stores such as screws, glass, paint can also be purchased, and it is sometimes possible to purchase from the P.W.D.

Stores.—The general procedure for stores is for the O. i/c of Stores to submit demands for Class A and B Stores annually in April, and they are procured through the A.O.D. E.L. and T. Stores are indented for annually in August.

For other stores the A.I.W. abstracts from each estimate those necessary, and indents direct on the War Office for them. These are sent out to Sierra Leone, consigned to the A.O.D. who clear them and hand them over to the R.E. on the Wharf. The A.S.C. provides transport on requisition by the R.E. There is generally a small reserve of Portland cement which can be drawn against for small works, and repaid when received from the United Kingdom, and quite lately sanction has been received to a reserve of £300 worth of stores to be similarly drawn against. *Care must be taken that repayments are punctually made.* The object of this is to lessen delay, and also to lessen the number of small indents which are continually being submitted to the United Kingdom. When the new system is in working order, a monthly or bi-monthly comprehensive indent for small works can be submitted which will lessen work both in the Colony and United Kingdom.

As before mentioned some stores can be procured locally and there are four firms who tender. Prices rule about the same as those supplied by the War Office.

Joinery has recently been made up by the S.M.E. It is of good quality and possibly a little cheaper than if made up locally. A point to be noted is that panelled work should be made up diagonally, *i.e.* the panel boarding should be put diagonally (*vide* Indian pattern type drawings), it is less likely to split. It must be remembered that the extremes of dryness and humidity are excessive, and no woodwork can stand with impunity the extreme dryness of the Harmattan wind and the damp of the rest of the year.

It is thought that some of the jalousie work is unduly solid :— the louvres might be thinner. Where light is required and where the jalousies are fixed or sliding, glass can be substituted for wooden louvres with success and economy.

A good deal of concrete work goes on, involving sometimes a considerable amount of casing. Some of this wears out, but it appears to have been the practice to use up any stuff that survived on incidental work. It is brought on charge and should all be marked. This will save having to estimate for the full amount required in each work where casing is required.

Nature of Buildings and Rough Specifications.—The buildings of old date at Tower Hill have walls of brick, some few of syenite and others of laterite, many are wooden buildings weather boarded, and lined with match board. Of late, reinforced concrete and concrete blocks have been used with success for the walls. The best and most economical will probably be the concrete blocks made with laterite aggregate, this will render steel framing unnecessary. One Winget machine is in work. A concrete mixing machine and engine is also on order.

All dwellings require, from the nature of the soil and climate, to be raised from the ground ; a height of from 2 to 3 ft. is sufficient. A concrete " seal " is laid on the surface of the ground ; in former buildings one finds this " seal " made of 4 to 6 in. of p.c. concrete with a rendered surface—this appears unnecessary. If 2 in. of laterite metal be well rammed and the surface dressed while ramming with old concrete rubbish or with a skin of cement and sand, it should be quite sufficient—and the same applies to plinth protection on the ground from 3 to 4 ft. round the walls. The practice has been to provide eaves guttering and down pipes with elaborate and deep drains to take away the roof water ; this is unnecessary ; small depressions sometimes occur in the eaves gutters and form a possible breeding place for mosquitoes. The soil will absorb most of the rain, if the plinth protection is given. The eaves gutters in most cases can be dispensed with, and the only drains really necessary are those for foul water. These should be saucer-shaped ; a number of old

slates from dismantled roofs have lately been obtained, and these make admirable bottoms for such drains. Concrete is not desirable for the bottom of drains which have to be swept out, or for those of any steepness; the concrete gets worn out very quickly (see Roads and Drains).

Floors.—These are best made of concrete reinforced either by expanded metal or bars. Floors and also the walls have to be supported on R.S. joists or concrete beams. Much of the steel work found in former designs can be dispensed with, *e.g.* the joists can be laid direct on concrete piers—small columns 2 to 3 ft. high on top of piers are quite unnecessary.

Roofs.—The older roofs have wooden trusses—these can advantageously be of steel in the future, fixed direct on the concrete block walls with steel bedplates or shoes bolted down to the walls; steel columns are quite unnecessary unless reinforced concrete panels are used, and this can only be economically done (if then) if the walls are not more than 4 in. thick; such walls should be sheltered from the weather, even 6 in. is hardly thick enough to keep out the damp.

Roof Coverings.—These were formerly of slate, but this kind of roof has now practically disappeared. Experiments have been made with asbestos sheets laid on boards with felt between. The P.W.D. used them extensively and found them a failure, and are now re-covering practically new buildings with C.I. sheeting. Only two R.E. buildings have these roofs; both have been laid less than six months, one appears so far satisfactory but in the other, though remaining water-tight, the slates appear to have buckled or crept and a series of undulations have appeared. Corrugated-iron sheeting on the whole is the best roof covering; it should be painted after being up about a year when a small amount of rust has formed. Reinforced concrete roofs would no doubt be desirable but labour is not sufficiently skilful nor plant adequate to make these in large panels to be water-tight.

Preservation of Ironwork.—It is very extraordinary how the ironwork in Sierra Leone resists rusting influences in spite of the prevailing damp and exposure to sea air. It may possibly be due to a deficiency of ozone and nitric acid, there being no seaweed to give these off. Oxide paint seems to fulfil all requirements for joists and roofs; the latter should be slightly rusted before the paint is applied strange as it may seem. A good receipt is to sprinkle sand over the wet paint, or to paint the joists with thick cement grouting, especially if a little rusted.

For native troops, huts are constructed—these consist at present, as regards the walls, of poles filled in with wattling and mudded over—the roof being formed of poles 2½ to 2 in. thick or less with battens over, and very thin corrugated-iron sheets. The huts are in bad repair, and a new type of design with steel frames have been approved. The sheets should be of considerably stouter gauge.

As a rule roofs, doors and windows are kept up by the R.E. and the mud walls by the troops at their expense.

General Design.—Most of the buildings are too low, the height of the rooms should seldom be less than 11 ft. even in Wilberforce and Hill Station. In single-storied buildings ceilings should be omitted. There should be louvred ventilators in gables to bring a draught through the underside of the roof.

Eaves should be wide as the drift of the rain is very great; tornadoes come from the N.E. to begin with, but the direction changes through a wide angle, so the northern sides of houses should be specially protected.

The prevailing winds are:—November to March—North-East; April to July—South-West; August to October—West.

Labour.—No contractors for work exist in the Colony, though some English firms have made enquiries. All work therefore has to be done by direct labour, and constant supervision by the M.F.W.'s is necessary. Time sheets are to a large extent useless as most of the men cannot read or write, and the only check is by accurately estimating and constantly checking the estimate with the progress; it is not easy to get English-trained M.F.W.'s to do this. The native foremen are unreliable and the artisans of indifferent quality. The labour is excessive in cost and unsatisfactory; the negroes will not work unless compelled and constantly watched.

During the last year or so the prosperity of the country has gone up by leaps and bounds, with the result that both the trading community and the Colonial Government are extending their buildings rapidly; consequently labour is difficult to procure and unsatisfactory when obtained owing to competition in rates. The rates have gone up from 10 to 15 per cent. lately, and may be reckoned on rising for some time to come.

As regards the labourers, they are men who come into Freetown for work when nothing can be done on their farms, and at sowing and harvest time they all troop back to their homes for farming purposes leaving but few in Freetown. Even in the Protectorate close to their homes their services cannot be relied on, and labour is scarce all the year round.

The Sappers both European and Native are employed on the works, and the troops, especially those in the Protectorate, are also employed and receive working pay.

Labour is generally scarce from February to April and again from July to October. In the latter case it does not so much matter as not much work can be done during the rain, but the former period interferes with the end of the financial year and as much work as possible should be carried out during April, May and June.

Estimates.—Very considerable care needs to be taken in framing even approximate or cube-rate estimates. Recently the cost of both

material and labour has considerably appreciated, and former prices are not much as a guide unless 15 per cent. is added. The schedule of rates will shortly need complete revision, but as most of the items are framed for labour only, it is not much good reprinting until some finality as to cost of labour can be foreseen.

Estimates are taken out showing :—

(*a*). Cost of labour only.
(*b*). Cost of material only.

It is advisable to send any large estimate to have W.O. for check when forwarding indents for materials, and to ask that the actual cost of same be compared with the estimated cost so that any considerable difference may be detected at once and precautions taken to avoid excesses.

As contractors' measurements are not taken, the A.I.W.'s estimate for quantities should, as a rule, be sufficiently exact to cover the cost of the work, and to facilitate check of cost of work in progress by the D.O. or M.F.W.

Roads and Drains.—The roads throughout Freetown are practically ungraded and unmetalled. They follow the surface of the ground, generally by the nearest route, so that in places the gradient is very excessive.

All the important roads can be treated as hill roads and are unmetalled. Those belonging to the W.D. are few and the mileage small. The broader ones have inside ditches with cross-drains. On the steep grades the roads get badly eroded unless stone ridges are built across them to turn the water to the drains.

On narrow roads the same ridges are advisable, but it will be found more satisfactory to make the slope outwards and to construct a catch-water drain on the hillside above the road; this need not be lined with stone or concrete.

The roadside drains have been made deep and square, in some places the gradients are absorbed by stepping, but in others they follow the gradient. This latter is most unsound, the heavy rains bring down quantities of débris and small stones; and these moving rapidly over the bottom erode a concrete surface very quickly, and considerably damage even a laterite bottom. It is essential to step the drains and to make the bottom of slate or rock—the riser should be sloped about 30 degrees out of the perpendicular. The drains could with advantage be made much shallower and possibly wider.

The Public Works have under consideration a large scheme for improving the roads in Freetown for wheeled (*i.e.* motor) traffic. and the necessity must be reckoned with of bringing the few W.D. roads into line at no very distant date—such means of locomotion will undoubtedly much reduce the present heavy transport charges for carriers.

Tree Planting.—In the vicinity of some of the W.D. buildings, *e.g.* at Tower Hill and Mount Aureol, the bush has been cut with so much thoroughness that all the trees have also been removed. This is not altogether desirable, a few trees are needed for shade to roads and to improve the landscape. Recently trees, chiefly of the rubber species, have been planted along some of the roads; and this should be continued yearly. They should be planted early in August.

Names of the best and quickest-growing species can be obtained from the Conservator of Forests, who also very kindly will supply young trees from his nurseries when available.

A hole should be excavated and filled in with good soil, and guards should be placed round them to prevent damage from cattle and goats; the inhabitants of Freetown have the grazing rights over Tower Hill. When planted near buildings, care should be taken to place the trees so that the branches will not overhang them.

Care is needed at the commencement of the dry season in February to prevent the young trees being destroyed when the grass is burnt; small areas should be cleared round each tree in December.

Climate as it affects Works.—There is but small variation in the climate. The mean temperature varies as a rule between 65 and 95 degrees. This is favourable for concrete work and expansion joints are hardly necessary, nor, except for very long spans need provision be made for expansion in ironwork.

The dampness is exceptionally favourable for good results in concrete.

Rain falls heavily during the latter half of June, July, August and September—it is preceded and followed by violent tornadoes and precautions must be taken against high winds.

During December, January and February the Harmattan blows—this is an exceedingly dry wind from the desert to the N.E. and is heavily loaded with fine particles of sand; it dries up and shrinks woodwork and destroys the qualities of leather, rubber, and tar materials such as felt.

REVENUE AND CADASTRAL SURVEYS.

By CAPT. H. G. LYONS, F.R.S., LATE R.E.

UNDER the general term "Surveying," are included the measurements of the earth's surface which are made for many purposes; for each of these special factors are of primary importance, and the precise methods employed have to be selected accordingly; but there is no branch of the subject which has a wider bearing or a greater importance than the measurement and demarcation of landed property which is comprised under the terms Cadastral and Revenue Surveys. In each of these the size, shape, and location of each landowner's property have to be determined, and considerable precision is demanded especially in cadastral work. There is a well-defined difference in the scope of these two classes of survey when the terms are employed in their strict sense, for while the ownership, size, and the quality of the land of each holding suffice for the most part for a Revenue Survey, which has for its object the equitable imposition and ready collection of a land tax, a cadastre is required to provide a full record of all claims, servitudes, and evidence of ownership as well, so that it may establish the owner's title to the property. Under certain conditions the one may pass by gradual development or by a subsequent revision into the other, but in any case the determination of property boundaries, which can usually be indicated with precision, demands work of a high order if the measurement of many thousands of small holdings is to be so controlled as to maintain a high standard of accuracy. It is not necessary to discuss at length the disputed derivation of the word "cadastre," but as strictly used it connotes a record of individual holdings, their size. location, and character, their ownership, and all rights and liabilities connected with them, so that their measurement and the graphical record of such measurements on a map or plan is only a portion, though a very important portion, of the information needed. At the same time the map is not an essential part of a cadastre although it is now almost invariably associated with it; but whenever it is prepared it must show primarily the boundaries of properties irrespective of their relation to topographical features. Hence the 1 : 2,500 maps of the Ordnance Survey are not true cadastral maps, but are large-scale topographical maps since the details that they show, walls, hedges, railings, etc., are topographical features which may not and do not in every case coincide precisely with the property boundaries.

These classes of survey are not at the present time officially represented in this country, though in most European countries, in the Oversea Dominions and in many Crown Colonies, they are of extreme importance, and, as a special application of the principles of land measurement, they merit more attention here than they have usually received; for in their employment over large areas, or in densely populated districts, they demand work of the highest precision that can be executed in order that the exact location of each holding may be adequately controlled.

In most European countries the great State Surveys, in their present form, date from about a century and a-half ago, and owe their inception rather to the military needs of the State at that time, than to fiscal requirements. Consequently their first basis was essentially topographical, and their object was to produce maps of sufficient detail and accuracy to facilitate the movement of bodies of troops through the country, and to indicate the tactical positions available. Large-scale maps were not therefore at first essential, and it was only later on when administrative needs became urgent that these were undertaken. In this country we are still in this position, for the recent enlargements of the 1 : 2,500 map, which have been produced to facilitate the valuation of land for the purposes of land tax, can hardly be regarded as a Revenue Survey properly so-called.

On the Continent most countries have long had land surveys of a local character, but it was not until the 18th century that any steps were taken for the control of these by triangulation of the highest accuracy carried out by the State. As the outcome of this Germany, Austria, Italy, Holland and Belgium have now detailed surveys of all landed property, which are being constantly revised and brought up to date, and which consequently demand the services of a large profession of surveyors who are constantly engaged in land measurement of high precision. In France the matter has not yet proceeded so far. The "cadastre" of Napoleon's time is still in use, and though a Commission has been studying the question for many years and has reported voluminously upon it, no Cadastral Survey of the whole of France yet exists as a single co-ordinated piece of work.

The essential difference between Cadastral and Topographical Surveys is to be found in the fact that the former are concerned with locating the boundaries of landed property, while the latter indicate the boundaries of natural features, and the visible results of man's handiwork on the earth's surface, a distinction which is intimately related to the methods of work, for property boundaries can be defined much more precisely than such natural limits as a seashore, the bank of a river, the foot of a hill, or the floor of a valley. Much more accurate methods may therefore be employed, and wherever landed property is situated in densely populated tracts its value is greatly enhanced, so that the highest precision is demanded in its

demarcation. For this reason Cadastral Surveys justify the additional expenditure incurred in executing a triangulation of the greatest accuracy, and work of such a character as to contribute to the solution of the highest problems of geodesy can be profitably utilized in controlling the various grades of measurement which go to determining the location of the boundary marks of individual holdings.

Thus, in Cadastral Surveys, the scale of the map, and consequently the methods of surveying to be employed, are controlled by the value of the land which is being measured, or perhaps, to speak more correctly, by the size of the plots or holdings into which it is subdivided. The scale selected must therefore be large enough for the purposes of the cadastre, and is in most cases larger than that which is required for the topographical maps of the same district, so that the term cadastral is often used to designate a large-scale survey of land in which the boundaries of each holding and plot are located accurately by measurements, whether they coincide with topographical boundaries or are marked artificially, or are even without any visible indication, that is to say cadastral maps are governed by special conditions which do not occur in the case of maps which are designed for purely topographical purposes. In most European countries, they may be described as being maps on a large scale which form the basis on which the State land tax is regulated, and they are to be considered as legal documents relating to the possession, the cultivation, the employment and the value of land. For this reason it is essential that the whole of the work should rest securely on actual measurements, and not be sketched in; all observations must be recorded and be available for subsequent verification, so that graphical triangulation with the plane table is undesirable; numerous permanent marks must be provided so that changes, encroachments, and subdivision of holdings can be rapidly and accurately effected at any time.

With this object, a very close network of triangulation is executed in connection with the triangulation points of the main survey of the country, and a complete measurement based upon them is carried out by very careful determinations of length and angle. Theodolite traverses increase greatly the number of permanently marked points of reference which the triangulation provides, and in the field the detail measurements are recorded in dimensioned plans drawn to scale which are preserved as the original documents, and from this material the cadastral maps are prepared. These are essentially prepared as site plans, that is, they do not indicate the natural form of the ground, nor do they show heights, depths or slopes, while the scale varies with the size, cultivation and importance of the area measured, such scales as 1:500, 1:2,000, and exceptionally 1:4,000 being employed. A Cadastral Survey is sometimes carried out

over the whole of a country as a single piece of work, but it is oftener executed by villages or other administrative areas; the maps in such cases are prepared by villages, several sheets being used if necessary. In consequence of the accuracy with which small details are measured up and plotted, cadastral maps of all kinds, field, forest, river and town maps are well suited for supplying a basis for the cartographical representation of a country, and may be reduced to any smaller scale, revised, completed in relief features and brought up to date to form topographical maps. This description applies more strictly to the Cadastral Surveys of Germany, but may be extended with but little modification to those of the other European countries, the essential condition of a cadastral map being that it should show the boundaries of property, whether these coincide with the topographical features or not.

While therefore a cadastral map is one which shows property boundaries and in which topographical features are considered as being of secondary importance, it is not essential that the scale should always be large, for it will depend mainly upon the extent to which the land is subdivided and partly also upon its value. Where the land is owned in large tracts and is of little value, a comparatively small one may suffice. As a rule the scale to be selected for any area is determined by the average size of the holdings according to certain rules, and in Prussia, these are:—If the average size of the plot is greater than 0·5 of a hectare the scale used is $\frac{1}{2000}$; from 0·05 to 0·5 of a hectare, $\frac{1}{1000}$; if less than 0·05, $\frac{1}{500}$; whilst for wood, marshes, waste areas and lakes a scale of $\frac{1}{4000}$ is used.

The original scale of the Austrian cadastre was 1 Vienna inch ($\frac{1}{72}$ of a Vienna klafter) to 40 klafter, or 1 : 2,880; cities and the larger towns were mapped on the scale of 1 : 1,440, as also was land which was divided into small plots; in Vienna the scale of 1 : 720 was also employed. In 1873, when the metric measures were introduced into all branches of the public service, the scale of 1 : 2,500 was introduced for all future surveys. In cases where the land is highly subdivided, the maps are plotted to the scales of 1 : 1,250, or 1 : 625.*

In Würtemberg the normal scale is 1 : 2,500, but 1 : 1,250 is used near towns and villages where the holdings are small. At the same time most countries adopt one scale as that to be used wherever there is no good reason for the use of a special one, and in Europe this is usually 1 : 2,500, or some scale approaching this.† But the adoption of a single scale throughout a large area would usually be unsuitable, since it would probably be extravagantly large for the scantily

* *Instruktion zür Ausfuhrung der Vermessungen . . . für die Zwecke des Grundsteuerkatasters.* Wien, 1907.

† *Amts-Blatt des Königlich Württembergischen Steuerkollegiums* No. 2. Stuttgart, 1895.

populated districts, and inconveniently small for the towns and cities. A tabular summary of the scales in use in certain countries is given below :—

Scales in Use for Cadastral Maps.

Prussia.	Würtemberg.	Bavaria.	Baden.	Saxony.	Austria.	Italy.
—	—	1 : 5,000	—	—	—	—
1 : 4,000	—	—	1 : 4,000	—	—	1 : 4,000
—	—	—	—	—	1 : 2,880	—
—	1 : 2,500	1 : 2,500	—	—	1 : 2,500	—
1 : 2,000	—	—	1 : 2,000	1 : 2,000	1 : 2,000	1 : 2,000
—	—	—	1 : 1,500	—	—	—
—	1 : 1,250	1 : 1,250	—	—	1 : 1,250	—
1 : 1,000	—	—	1 : 1,000	1 : 1,000	1 : 1,000	1 : 1,000
—	—	—	1 : 750	1 : 750	—	—
—	—	—	—	—	1 : 625	—
1 : 500	—	—	1 : 500	1 : 500	—	1 : 500
—	—	—	—	1 : 200	—	—

The accurate measurement of landed property is older than any topographical survey, and it had already in the earliest historical times reached a very advanced stage in those regions where human civilization was most highly developed. In the very early times of Egyptian history a "numbering" of the Royal possessions was made throughout the land by the officials of the treasury every two years, and this would be a sort of verificatory survey of State property which doubtless included herds as well as lands. This biennial census was so regular a procedure of the administration in these early times that events in the reign of the king were dated with reference to it.

A little later we meet with records of the registration of property, for in the third dynasty, about 3000 B.C., the property of a high official Methen,* was recorded on the walls of his tomb at Saqqara, and is stated to have been duly registered as belonging to him in the royal archives or registry. There must, therefore, have been at this time a well-developed method of measuring the land and of computing the area of properties. It was not long before the registration of land and its measurement became highly organized, as would be essential in a country where all payments of taxes were made in kind and rent was paid in the same way.

Another of the tombs of Saqqara, that of a certain Mes,† furnishes us with information of exceptional interest. Certain lands near Memphis which the Pharaoh Amosis (1580 B.C.) had conferred on an ancestor of Mes named Neshi were, during the minority of Mes

* Breasted, *Ancient Records*, Chicago, pp. 171–5

† Loret, *Ägyptische Zeitschrift*, 39 (1901), Moret, *ibid*; Gardiner, *The Inscription of Mes, Untersuchungen zur Geschichte und Alterthumskunde Ägyptens*, IV., 3, 1905.

claimed by a certain Khay as his property. A lawsuit followed in which Khay produced false title deeds whereupon Nubnofret, the mother of Mes, appealed to the official registers, saying, "Let there be brought to me the registers from the Treasury and likewise from the Department of the Granary of Pharaoh." A Commission was sent by the Court to make extracts from the registers, but by means of falsified copies Khay gained his case, but was, however, nonsuited on appeal when the evidence of many neighbouring landowners was taken.

In later times, about 900 or 850 B.C., the register of the lands and springs in the Oasis of Dakhla is referred to in an inscription which tells of a lawsuit concerning the ownership of a spring; 19 years elapsed before a decision was obtained.*

Thus, the owner's name, the area of the property, its position and the tax due from it were regularly recorded, and, in the New Empire at least, duplicate registers were kept in the Treasury and the Royal Granary.

The same system of land registration continued down into Arab times as papyri dating from Græco-Roman sites show, and the system in the form in which it has survived has just been brought into accord with modern methods of measurement and computation. These early cadastres were records of the area of each holding, and included a description of its position as defined by the neighbouring properties, but cadastral maps, properly so-called, were not prepared so far as we know. Still holdings were carefully measured up with cord or rod, and the Chief Measurer of the property of the god Amen at Thebes was a temple official of high importance.

Unquestionably the great fertility of the Nile Valley, the density of its population rigidly confined between two vast expanses of desert and restricted to an area which has varied from about four to seven million acres, according as how much was marsh and waste land at the time, and especially the annual setting out of holdings on the flood plain as soon as the inundation was over, gave a special importance to careful measurement of the land, and the recording of each man's area and its quality.

In Babylon, too, where a fertile river valley supported an advanced civilization, land measurement was of great importance, and the clay tablets from Tello, on which the records were made, have preserved to us from the earliest times of its history, cadastral plans of properties, and much information of like character.

No map of landed property in ancient Egypt has come down to us, but on the tomb walls we meet with representations of land measurers at work. Their methods of land measurement are represented on the walls of the tomb of one Menna† at Thebes, a

* Spiegelberg, *Recueil de travaux, etc.*, 1899, p. 12.
† Borchardt, *Zeitschrift für Ägyptische Sprache*, 1905, p. 70.

scribe of the fields and inspector of the boundary stones of Amon. The tomb, which is situated in that portion of the Theban burial ground known as Sheikh Abd el Qurna, has recently been cleared out by Mr. R. Mond. The scene depicted shows two chainmen measuring a field of corn with a long cord on which are knots or marks at intervals which seem to be about 4 or 5 cubits in length: each also carries a spare cord coiled up on his arm. Beside them walk three officials, who carry writing materials and who are accompanied by a small boy carrying writing materials and a bag in which are probably documents and plans referring to the property. An old man and two boys also accompany the surveyors, and a peasant brings a loaf of bread and a bunch of green corn.

Papyri from Tebtunis give a detailed description of certain small plots of land on the east side of Crocodilopolis Arsinoe (Medinet el Fayum) between the road round the town and a large canal. The dimensions are given in *schoenia*, and the plots are of the usual small size; some belong to private individuals, one belongs to the queen, another is recorded as common land, while a public road between the private property and a public canal is separately registered. The same conditions may be exactly paralleled round Medinet el Fayum to-day.

Without doubt the land measurers of this period were but continuing the procedure of earlier times in the methods which they employed. Lines were measured along the heads of the plots, the breadth of each field being recorded as well as its length; from this the areas of rectangular fields could be calculated. Frequently the lengths of all the sides were recorded and the area was then computed by obtaining the product of the means of the opposite sides whatever the angles of the figure might be. The part of the village lands in which the line starts is described and then the detail measurements are recorded.

The Roman land measurers* developed a most effective system which spread through the Empire, and in their work laid the foundation of many of the local surveys of Europe.

Thus it may be seen that wherever land is fertile or thickly populated land measurement of considerable elaboration and accuracy is early found to be a necessity. In all countries, whether settled or in course of development, land of all kinds and qualities will fall within the scope of a Cadastral Survey, and one class will shade into another by imperceptible graduations so that classification is at all times difficult. As examples of the way in which the demands made upon this class of surveying may vary we may take:—(*a*). Forest and grazing lands. (*b*). Lands partially cultivated. (*c*). Good agricultural land. (*d*). Town property.

* *Die Römischen Agrimensoren*, Dr. M. Cantor, Leipzig, 1875.

Much land in Australia and other pastoral regions is of the first category and maps on scales as small as 1 : 126,720 will often meet all requirements.

The second class may be found plentifully in every country, especially in its more hilly districts, or in the low-lying unreclaimed parts such as river deltas. We may instance the Scottish Highlands, or the hill ranges of Cyprus, or the northern margin of the Nile delta, until its reclamation by means of the surplus water of the river ponded up by the Aswan Dam is an accomplished fact.

Fertile agricultural land has already been alluded to as having from the earliest times been measured and recorded with all the care and precision that its occupiers had at their command.

In each of such classes maps of a certain scale will show with sufficient accuracy the various holdings, and give such additional information as may be desired.

We may say that 1 : 25,000 to 1 : 100,000 for the first ; 1 : 5,000 to 1 : 10,000 for the second; 1 : 2,500 to 1 : 4,000 for the third; 1 : 250 to 1 : 1,000 for the fourth class will generally suffice.

A much higher accuracy of location will of course be required for the larger scales than the smaller, but in general it is more satisfactory as well as more convenient to extend the most accurate network of controlling triangulation over the whole area, filling in with more or less close networks of triangulation of lower orders according as more or fewer points will suffice for controlling the detail.

Wherever holdings are small and closely grouped together many additional points will be required, but if the main triangulation, of whatever order has been decided upon, has been completed over the whole area, it is a comparatively simple matter to prepare a local network of a lower order and a suitable density of points for any particular portion. In the same way so long as the control is of a sufficiently high order of precision, the scale of the map can be varied anywhere for town, or fertile area, or waste track without difficulty.

Where so high an accuracy is demanded over large areas, and where in one part holdings are small and in another they are large, the only means of effectively controlling such land measurements is to employ the best and most precise triangulation that time, means, local conditions and available staff will allow.

Triangulation of the First Order is no doubt the ideal control, wherein the triangular error is less than 1", but this is a counsel of perfection which can usually be attained only in fully settled regions where the population is fairly dense and the importance of an accurate Cadastral Survey is administratively recognized. In lands still in a more or less forward state of development, pressure is always exercised in favour of a survey of less efficiency which will be " good enough " for existing conditions; and it must be admitted that there are probably in such regions many other administrative reforms,

and projects of urgent importance to the community, so that to maintain that an efficient Cadastral Survey can only be executed on the basis of the most precise and complete geodetic triangulation is to demand what is in many cases unattainable at the time, and may prejudice unreasonably the whole project. Money, time, staff, and local conditions must all be given due weight in preparing a scheme for a Cadastral Survey, and here as in topographical work it may often be a sounder policy to push through a reasonably complete and efficient scheme so designed that revision may be effectively and economically undertaken at a later date, than to embark on an undertaking of higher precision which can advance but slowly at a time when the country urgently requires to proceed to the settlement of land revenue or the registration of real estate. Under such conditions three essential safeguards must be borne in mind as furnishing the guarantees for the permanent value of such work as is done, viz. :—

(1). Precise and permanent marking of points.
(2). Definition of the permissible limits of error in all the operations.
(3). Mathematical control of the whole work.

To these points I shall return later.

As a recent Royal Commission has reported against the compulsory registration of title to land in this country, we may dismiss from our consideration the special conditions which prevail here, and consider rather those which are met with in what we may term partially developed regions, such as are represented in the Crown Colonies and the Oversea Dominions.

From the East African Protectorate, the Gold Coast, Nigeria, Nyasaland, Sierra Leone, Uganda, British Honduras, Cyprus, Hong Kong, Jamaica, the Federated Malay States (Revenue Survey) and Trinidad, Cadastral Surveys or Land Surveys for the registration of property or the assessment of land tax are reported in Colonial Office Report (No. 775) for the year 1912–13, so that there is a large amount of this class of work in hand in regions where no complete triangulation or topographical survey of precision yet exists.

By means of " Invar " wires and tapes the measurement of bases has been greatly facilitated, and they may now be measured rapidly and with sufficient accuracy for use in any control triangulation which may be required. The error, co-efficient of expansion, and variation of length under different tensions having been furnished with the wires from an authoritative institution such as the National Physical Laboratory, one wire should be kept for measuring short-control lengths in the neighbourhood of the triangulation bases so that the wires employed in the latter may be verified before and after the measurement of the base. Since with apparatus of this character

base measurement has been so much simplified, it is frequently advantageous to increase the number of bases measured, and reduce the extent of triangulation network between each. In this way the accumulation of errors in the triangulation is controlled, and the network between adjoining bases can be computed, adjusted, and used for controlling the detail measurement at the earliest possible time. In Egypt where international agreement had imposed a limit of ten years for the completion of the Cadastral Survey, the work could only be accomplished by measuring frequent bases, and eight in all were used in surveying an area of about seven and a-half millions of acres of land.

On these bases is built up the best and most accurate triangulation that the means available and the conditions of work will allow. Triangulation of the First Order will rarely be practicable in the first instance, but Second Order Triangulation, in which the angular error of any triangle may not exceed 5", should be employed and should be kept at as high a standard as possible. Since the length of the sides will be of from 10 to 20 miles this Second Order network will have to be filled in by triangulation of the Third Order in which the angular error of any triangle will not exceed 15", and in both these orders of triangulation all angles of the triangles should be observed. 8-in. theodolites should be used for the Second Order and 6-in. instruments should be used for the Third Order, both being furnished with microscopes for reading the divided circles.

Average Length of Sides of Triangles in Kilometres.

Order.	Prussia.	Saxony.	Würtemberg.	Austria.	Bavaria.	France.	Egypt.
I.... ...	20 and over.	20 and over.	10–75	15–30	15–40	20–40	20–50
II. ...	10–20	10–20	4–30	9–15	5–15	15	10–20
III. ...	3–10	2–5	0·7–5	3–9	2–5	*	3–5
IV. ...	under 3	0·5–2	—	—	0·5–2	—	under 3

* Not yet up to the standard needed for cadastral plans. (See Reports of the Extraparliamentary Commission).

In this manner a network of points will be provided the position of each of which is accurately known, and all these points should be marked in a permanent manner so that the exact point of reference can be subsequently determined without doubt. The expenditure on this head is too often insufficient, and no item is more worth dealing with generously; examples are readily found, and in Egypt not a single point could be found in 1898 of all the points fixed

by the Cadastral Survey of 1878—1888 on which nearly half a million of money had been spent, and the whole work had to be redone. A careful record kept from the beginning of a survey of all triangulation points with the exact descriptions and a note of the degree of accuracy of each finally accepted position is an essential provision of every survey, but especially in cadastral work.

Where holdings are small and time is available it frequently happens that a triangulation of the Fourth Order in which the sides are from 0·5 to 2 miles gives a valuable control to the traverse and to the subsequent chaining of the detail measurement.

But even if the holdings are of moderate size more points than those furnished by triangulation of the Fourth Order are required, and these may be provided either by direct chaining or by a system of theodolite traverses. In the Ordnance Survey an elaborate system of chained triangles was used, but this is not suited to all conditions; straight lines are rarely in agreement with the property boundaries, and moreover accurate chaining over long distances or where detail is close and intricate needs much experience. Theodolite traversing is usually practicable and possesses the advantage that it can follow conveniently the most irregular boundaries; at each change of direction is a point the co-ordinates of which can be computed and corrected to bring them into adjustment with the controlling triangulation and by such computation a very effective control of the traverses is provided. At the time of survey it very frequently occurs that land is to be divided into groups of holdings such that, the land being of one quality, a single rate of tax can be fixed for the group, and in this way the revenue work is facilitated. In this case traverses can be carried round such areas with little trouble by suitably arranging the primary and secondary traverses and the traverse points furnish boundary marks for such fiscal units. Traversing with the theodolite is most advantageous where the intervening distances are long, but these must be limited by the rate at which errors of measurement increase. In practice the distance between adjacent traverse points is usually from 300 to 500 metres, and each distance is measured twice with a steel chain or preferably a steel band, and the mean error of such double measurement need not under moderately favourable conditions exceed 1 in 1,500. Each primary traverse should run from one triangulation point as directly as possible to the next triangulation point, and the closing errors both of direction and of the x and y co-ordinates have to be distributed over the traverse and the corrected positions of the traverse points thus determined. The number of these traverse points will naturally vary with the size of the holdings, the unevenness of the ground and the number of the obstacles on it. As an example the practice of the Prussian cadastre may be quoted, in

which 14 to 40 points per square kilometre, or about 35 to 105 per square mile according to the size of the holdings are employed.*

In Austria it is laid down that the number should be from 20 to 50 points per square kilometre, and in Bavaria from 20 to 60 are provided. In Egypt where the country is very easy for measurement, since the land is flat, and no woods or other obstacles occur, 14—18 is the usual number per square kilometre, but this would probably be increased in the case of registration of title being introduced. The number laid down for European surveys includes the increased number required in villages where house property has to be registered; but in Egypt traversing has not yet been done within the area occupied by the buildings of the village so that comparison should be with the open country only. The lengths of polygon sides are usually measured twice, either with 20-metre steel bands or 5-metre wooden rods, in Europe the latter being often preferred on rough ground; the angles are usually measured with 5-in. theodolites, readings being taken in both positions of the telescope.

Thus the traverse points mark the known positions on which all the detailed measurement depends, and the previous triangulation has for its object the control of the accuracy of many thousands of such traverse points which are permanently marked for future reference. In view of the very large numbers required, no elaborate form of mark is for the most part employed. In agricultural land in Europe a short length of earthenware drain-pipe sunk vertically in the ground with its top about 18 in. below the surface is often used; in towns, less destructible forms are necessary, and the mark is then made of metal and is set in a cast-iron box in the curb of the side-walk, or a bolt set flush with the surface of the pavement. In any case the permanency of at least a large proportion of these marks and facility in finding them when they are required to record alterations or to make periodical revisions are essentials.

It is necessary at an early stage to lay down what magnitude of error is permissible in the measurement of the lines joining these traverse points in order that the fieldwork may be controlled and an equal standard of accuracy be attained throughout the whole of the area under survey.

The discrepancies which are admitted between the two measurements of the side of a traverse or a chain-line, or between the distance apart of two points as determined by a traverse and by the triangulation, vary slightly in different countries; the formulæ which are used to express these permissible errors (d) in length are given in

* *Anweisung (IX.) für die trigonometrischen und polygonometrischen Arbeiten des Grundsteuerkatasters.* Berlin, 1903.

the following table which is taken from the regulations of the different surveys* :—

Country.	Linear Closure Error of Traverse.	Discrepancy between Two Measurements of any Line.
Würtemberg ...	I. $d=0{\cdot}010\sqrt{L}+0{\cdot}0005\ L$ II. $d=0{\cdot}015\sqrt{L}+0{\cdot}0006\ L$ III. $d=0{\cdot}020\sqrt{L}+0{\cdot}0007\ L$	The same.
Prussia...	I. $d=0{\cdot}01\sqrt{(4[L]+0{\cdot}005[L^2])}$ II. $d=0{\cdot}01\sqrt{(6[L]+0{\cdot}0075[L^2])}$ III. $d=0{\cdot}01\sqrt{(8[L]+0{\cdot}01[L^2])}$	$d=0{\cdot}01\sqrt{(4\ L+0{\cdot}005\ L^2)}$ $d=0{\cdot}01\sqrt{(6\ L+0{\cdot}0075\ L^2)}$ $d=0{\cdot}01\sqrt{(8\ L+0{\cdot}01\ L^2)}$
Saxony...	I. $d=0{\cdot}000654$ [L] for steel band II. $d=0{\cdot}000951$ [L] ,, ,, ,, $d=0{\cdot}0002133$ [L] for rods	The same.
Austria...	I. d=as for II. but $-20\ \%$ II. $d=0{\cdot}0006\ L+0{\cdot}02\sqrt{L}$ III. d=as for II. but $+20\ \%$	The same.
Egypt ...	(As for Prussia).	—
France...	$d=0{\cdot}10+0{\cdot}012\sqrt{L}$	I. $d=0{\cdot}008\sqrt{L}$ have been proposed. II. $d=0{\cdot}0012\sqrt{L}$,, ,, III. $d=0{\cdot}0016\sqrt{L}$,, ,,
Italy† ...	I. $d=0{\cdot}015\sqrt{L}+0{\cdot}0008\sqrt{L}+0{\cdot}1\sqrt{n-1}$ II. $d=0{\cdot}020\sqrt{L}+0{\cdot}0008\sqrt{L}+0{\cdot}1\sqrt{n-1}$ III. $d=0{\cdot}025\sqrt{L}+0{\cdot}0008\sqrt{L}+0{\cdot}1\sqrt{n-1}$	I. $d=0{\cdot}015\sqrt{L}+0{\cdot}0008\sqrt{4}$ II. $d=0{\cdot}020\sqrt{L}+0{\cdot}0008\sqrt{L}$ III. $d=0{\cdot}025\sqrt{4}+0{\cdot}0008\sqrt{L}$

These permissible errors may be best exhibited by taking a few lengths of polygons and comparing the errors (in metres) which the different surveys would admit :—

Sum of Sides.	Würtemberg.			Prussia.			Saxony.			Austria.		
							With Steel Band.		With Bars.			
	I.	II.	III.	I.	II.	III.	I.	II.		I.	II.	III.
200 metres...	0·24	0·33	0·42	0·32	0·39	0·45	0·13	0·19	0·04	0·3	0·4	0·5
500 ,, ...	0·47	0·64	0·80	0·57	0·70	0·81	0·33	0·48	0·11	0·6	0·75	0·9
1,000 ,, ...	0·82	1·07	1·32	0·95	1·16	1·34	0·65	0·95	0·21	1·0	1·23	1·48
1,500 ,, ...	1·14	1·48	1·82	1·32	1·61	1·86	0·98	1·43	0·32	1·34	1·67	2·0

* I., II. and III. refer to easy, moderate and difficult ground.

n = the number of points in the traverse, including both the first and the last.

† *Istruzione sulle Poligonazioni*, 1889.

In Egypt the same limits were employed as in Prussia and this accuracy was attained by the Egyptian surveyors without serious difficulty.

In closing on a triangulation point the angular error which has been accumulated in the traverse is ascertained and this may not exceed a certain amount, which is laid down in every survey as the following table shows :—

Permissible Difference in Closure of Traverses.

Number of Angles.	Prussia. Würtemberg.	Saxony.		Austria.	Egypt.*
		Steel Band.	Rods.		
4	3′ 0″	2′ 0″	0′ 46″	2′ 30″	3′ 0″
8	4′ 12″	2′ 50″	1′ 05″	3′ 32″	4′ 12″
12	5′ 12″	3′ 28″	1′ 20″	4′ 20″	5′ 12″
15	5′ 48″	3′ 52″	1′ 29″	4′ 50″	5′ 48″
Formula ...	$1' 30\sqrt{n}$	$60''\sqrt{n}$	$23''\sqrt{n}$	$75''\sqrt{n}$	$1' 30''\sqrt{n}$

* For town plans on 1 : 1,000 the formula is $45''\sqrt{n}$.

In all cases where a Cadastral Survey is in progress or is contemplated, such as the Crown Colonies or in outlying portions of the Oversea Dominions, a ready-trained staff will not probably be available in the first instance, but will have to be organized. This must depend largely on the *personnel* which is available, and in the Crown Colonies the majority will probably be drawn from the inhabitants of the Colony and may have but an elementary knowledge of surveying and the branches of technical knowledge which are most required. Here the problem is to divide the work into successive simple stages, each of which can be efficiently carried out by the staff available, and at the same time to maintain a supervision and control sufficiently close and stringent to ensure the necessary standard of accuracy being maintained.

In the Dominions a much higher grade of surveyor will be available, so that the problem is different, and here it will be important to economize the surveyor's time and energy to the utmost in order that his skill and knowledge may be available for the more technical parts of his work, and purely routine operations may be rendered as speedy and as little irksome as possible. Whether it is necessary to employ an imperfectly trained and educated native staff, or to get the largest out-turn from a skilled staff comparatively few in numbers, it is

universally recognized in these days that work must be planned and staff organized to this end. Cadastral surveying involves a vast number of simple computations in order to obtain the co-ordinates of the thousands of traverse points, and of products in determining the area of holdings; these thousands of points have to be accurately plotted on the field sheets from the co-ordinates so determined, and long lists of areas have to be totalled and verified in the land registers. All this can be done rapidly and accurately by a native staff of very small educational acquirements if the work is arranged so as to make use of modern mechanical appliances for computing and plotting. Multiplying machines, of which there are now many reliable patterns, enable the computation of L sin θ and L cos θ (where L is the length of the side in a traverse and θ its azimuth angle) to be carried out rapidly in combination with a suitable table of natural sines and cosines. These machines are also indispensable for computing areas, while adding machines greatly facilitate the totalling of plot areas, etc. The advantage of such machines is not merely that they enable unskilled computers to be employed, but also that the mental effort involved is much less than the using tables of logarithms or even traverse tables, so that the work can be carried on longer without prejudice to its accuracy.

In plotting the numerous determined points from their co-ordinates an instrument known as the co-ordinatograph* is of the utmost value. By its aid unskilled workers can after a few days' practice plot points to an accuracy of 0·1 m.m. at an average rate of from 30 to 40 points an hour.

Similarly, a skilled staff will be greatly assisted by the same aids in performing the more laborious part of their work, and at the present time in some surveys all geodetic computations are so arranged as to be conveniently made with the aid of such computating machines. But in order to gain the fullest advantage from such methods suitable arrangements must be made for their direction and control; and in all surveys of this nature, where the accuracy of areas and of boundaries is of special importance, there is great advantage in so arranging the work that all the computations of triangulation and traverse observations, as well as all projecting of map-sheets, and the plotting of the computed positions of points, are done in a special office in which the computing staff work under the superintendence of a qualified mathematician. In this office he receives each piece of observational work and treats it as a mathematical problem; here it is examined by computation and either rejected as exceeding, or passed as falling within, the permissible limits of error. Moreover as all the neighbouring observations have passed or will shortly pass through his hands, he can usually indicate at once which piece of work should be repeated to

* Made by Coradi, Zürich.

locate an error, such as may for instance have thrown out a portion of the triangulation network.

Administrators not infrequently object to the staff being employed in office during the working season, but as a general rule much time, money, and work is economized by keeping the chief of the computing office at his special work. He has much to get ready in order to deal quickly with the heavy accumulations of the material which is continually being received from the observers in the field, and the standard of accuracy which can be maintained is largely dependent on the efficiency of his control, and the thoroughness of his examination. Such an office if properly administered and efficiently directed is the best safeguard against fudged observations and slovenly measurement, since it deals with the results obtained quite independently of the field parties; further, much valuable advice is obtainable from such investigations as to whether any portion of the work is carried on at a standard of accuracy which under the circumstances is uneconomical, or whether increased accuracy at any point would be worth the additional outlay involved. No Director of Survey who has had the assistance of a skilled mathematician in charge of his computing office would ever willingly dispense with such an important aid in advancing the economy and accuracy of the work.

When all traverse points have been marked in the ground, the chain survey of the holdings becomes a simple matter, but even if the measurements are entered up in a chain book, a plotted field sheet on which the traverse points are shown correctly plotted, so that between them the detail can be filled in as it is measured up, and on which all plot boundaries are drawn in, is a necessity. Offsets should be kept of moderate length, and in Prussia those of over 10 metres in length must be taken with the aid of a cross staff, and preferably with an optical one; if longer than 40 metres, a tie line must be measured; those by which boundaries are fixed may not be longer than 10 metres. In Saxony, offsets to boundaries may be 10 metres long; any which are over 15 metres in length must have a tie line; and none, though taken with a cross staff, may be longer than 50 metres in level country, or 25 metres in uneven parts. In Austria the cross staff is to be used for offsets to well-defined points over 4 metres, to less definite points over 10 metres, and the limit of length for them is 50 metres on level ground and 25 metres on rough ground. In the Egyptian Survey, the limit for these is 20 metres, and the cross staff is always used, but hitherto it has not been an optical one.

Frequent reference to the owners of property must be made in the course of the work, and the field sheet is a great assistance in this. The amount of work which this part of the survey involves will vary greatly with the shape and arrangement of the holdings. Those which are approximately rectangular and

which lie parallel to one another present little difficulty, though cases occur where such holdings are but 3 or 4 yards wide and as much as 800 or 1,000 yards in length. Such exceptional holdings are to be found in the rainless irrigated land of Egypt where it is essential that every holding should abut on a supply canal, or in the plain of Northern Prussia where free access to a drainage channel is equally important. Irregularly-shaped plots and those which are scattered through poor and uncultivated land require more work than a fertile tract. But usually the areas of holdings are also to be computed from the field measurements, so that sufficient must be made to enable this to be done unless graphical computation of areas is admitted. These field sheets, or "Handskizze" as they are termed in Germany, must therefore contain full indications of these measurements so that the area computations can be accurately made from them. These field sheets either in the form that they are made out in the field, or fair copies in which all measured dimensions are plotted, become the documents which are preserved in the Cadastral Office for future reference, and from which cadastral maps are published if publication is a part of the scheme. Such dimensioned field sheets differ from the 1 : 2,500 sheets of the Ordnance Survey, since, besides being drawn to a scale, they also contain all the measured dimensions and offsets so that the whole of the information which defines the location of a holding, its shape, and its area, is given thereon, and thus furnishes the evidence which the registration courts demand.

With such dimensioned plans and a system of traverse points permanently marked on the ground, transfers of property, division of holdings, rectification of boundaries, expropriation of land and all the many operations which are continually needed in connection with the land of every civilized community may be made with certainty and accuracy whether they are situated in their open cultivated lands, or in the crowded streets of their cities.

The next operation after the location and measurement of all the holdings is the determination of the area of each.

The areas of plots are usually taken out firstly by mensuration and then for the second time graphically. In the Cadastral Survey of Saxony, the disc planimeters of Coradi of Zürich are used for taking out the areas of plots on the scale of 1 : 1,000, two independent determinations being made. It is maintained that the results of long and careful investigations show conclusively that the difference between two determinations of area with these instruments, when shrinkage of the map-sheet has been allowed for, does not exceed that occurring between two computations of the same if these are made in different ways; *e.g.* firstly from the measured dimensions, and secondly from the co-ordinates of the angles of the plot.

The next control is to determine the area of groups of plots up to about 30 in number with the planimeter, and to compare the result with the sum of the plot areas.

In the Prussian Survey not more than 60 hectares may be taken on the scale $\frac{1}{4000}$; 20 on a scale of $\frac{1}{2000}$; 5 on a scale of $\frac{1}{1000}$; and 1 hectare on a scale of $\frac{1}{500}$.

The final control is the comparison of the area of projected map-sheet with the sum of the portions which it comprises.

The permissible difference (a) between the computed area and the graphical control is $0{\cdot}01\,(60\,A \times 0{\cdot}02\,A^2)$, for the scale 1 : 2,000 where A is the area of the plot. In Austria the computation of areas is carried to a square decimetre for parts of plots in towns, and to a square metre in ordinary plots. The control groups of plots are :—

30—50 hectares on the scale 1 : 2,500,
8—12 ,, ,, ,, 1 : 1,250,

and generally they occupy about 5 to 8 square decimetres on the map. Such groups are usually taken to coincide with polygon sections.

The formulæ used for determining the permissible differences in area between two independent determinations are :—

Prussia ... $a = 0{\cdot}01\sqrt{(60A + 0{\cdot}02A^2)}$ a and A being in units of 100 square metres.

Würtemberg $\begin{cases} a = 0{\cdot}25\sqrt{A} + 0{\cdot}00075A \\ a = 0{\cdot}5\sqrt{A} + 0{\cdot}00075A \\ a = 0{\cdot}75\sqrt{A} + 0{\cdot}00075A \end{cases}$ Under different conditions.

Austria ... $a = 0{\cdot}0001A + 0{\cdot}5\sqrt{A}$.

The formula for Austria is that used for the scale of 1 : 2,500; those for other scales are :—

For scales 1 : 1,250 and 1 : 1,440 $a = 0{\cdot}001A + 0{\cdot}25\sqrt{A}$.
,, ,, 1 : 625 and 1 : 720 $a = 0{\cdot}001A + 0{\cdot}125\sqrt{A}$.
,, scale 1 : 2,000 ... ... $a = 0{\cdot}001A + 0{\cdot}4\sqrt{A}$.
,, ,, 1 : 1,000 ... ... $a = 0{\cdot}001A + 0{\cdot}2\sqrt{A}$.

When the areas of plots are taken out graphically by two independent operations, as in Egypt, the results can be checked (1) by determining planimetrically or by computation of the traverses the area of a group of plots amounting to about 80—100 acres, and (2) by the area contained in each projected map-sheet.

The planimeter is too well known an instrument to require description here, but it may be stated that the special form of the polar planimeter known as the compensation planimeter* has been found very satisfactory. It admits of the movable arm being used on both sides of the polar arm, which has the advantage of giving a compensation for any non-parallelism between the axis of the roller and the movable arm, for it can be shown theoretically that, if the required area is measured once with the pole on the right and once with it on the left, the error due to this non-parallelism changes sign and so

* Constructed by Coradi of Zürich, and others.

disappears from the mean of the two measurements. To take full advantage of this compensation, the planimeter must be disposed as symmetrically as possible with respect to the area to be measured, in the two positions.

Each instrument is checked every day on which it is used, with the special radius provided which enables accurately known areas to be measured, and, if necessary, is properly adjusted. The regular use of the radius for checking the adjustment of the planimeter is important when unskilled computers have to be employed, for it gives an inspector a measure of the instrumental error, and so enables him to detect readily indifferent work on the part of the computer. If, using the radius, the average difference between the results with the pole to the right and to the left is, say, 1 per thousand, an examination of the pairs of results obtained for the areas of holdings, will show whether the computer is adding materially to this difference by following incorrectly the boundaries of the figure which he has measured.

So much on the part of the State, but it should be incumbent on every landowner to mark the boundaries of his property in such a manner as to indicate them precisely. It is usually laid down that marks of a suitable character shall be placed on the boundary of each property so that the straight line joining them shall determine the holding. This general marking of property is a large and expensive operation, and in some cases where it has been introduced, and was not previously the general custom, the State has borne the first cost of carrying it out.

When the measurements are complete and have been checked and passed the fair map is drawn from the field sheets and is kept as a document to accompany the Land Registry. In some countries, *e.g.* Austria, Würtemberg, Bavaria, India, Egypt, etc., these land maps are printed; in others, *e.g.* Prussia, France, the Canton of Geneva, etc., the originals are kept and tracings of any portion are supplied as required. If it should be decided to print the maps then this should be done at the headquarters of the survey, for a poorly-printed map which is available at once is far more useful than a well-executed one which is received some months later, by which time a host of changes due to sales, transfers, etc., will have accumulated.

Besides the foregoing technical matters there are others which cannot be learnt beforehand, but which must be studied on the spot, and the necessary modification then made in the procedure which is adopted. Some of these are primarily physical and are connected with the local conditions of the country, others are social and relate to the customs of the inhabitants, but both classes require local knowledge on the part of the Director of the Survey.

Where parts of the country are but partially reclaimed large tracts may need little more work than traverse lines around their borders, but provision must be made for extending work over these

tracts at any time that their improvement is taken in hand. The relief of the country may be so broken up that continuous cultivation is impracticable and isolated patches alone occur, as in "The Hummocks" in the southern foothills of the northern hill range of Cyprus. Here traverse points must be numerous to assist the detail.

Where the climate and soil are favourable cultivation may be carried up the steepest hillside by terraced holdings, as in the Rhine Valley, in many parts of Italy, in the southern hill range of Cyprus, etc., and here the steepness of the slopes offer considerable difficulties to the surveyor; in warm climates such situations are often highly fertile and the accuracy necessary is as high as on alluvial plains. In some countries trees are owned separately from the land, *e.g.* fruit trees in Tyrol, date palms in Egypt, olive and fig trees in Cyprus, and though these are not shown in the maps, they are recorded by number and reference to the plot in which they stand.

Social customs are naturally more difficult to deal with than physical conditions, for the land surveyor is always regarded with suspicion, and often with disapproval.

Where a cadastre is being instituted for the first time to replace an old and perhaps inaccurate system, any reduction of a landowner's taxable area in course of its remeasurement and recomputation of its size by accurate methods, is regarded as a fraud upon the owner who has thereby lost some of his property. Thus the Egyptian methods of computation derived unchanged from the earliest historic times, and which are still in use in the villages, tended to show the area of a plot as greater than it really was. Consequently the correct surveying of property produced thousands of complaints that land had been deducted from a property whereas in fact the alleged deficient area had never existed. In Cyprus on the other hand the popular unit of area is slightly larger than the legal unit, so that each landowner's property seems to have been increased and complaints of incorrect area are comparatively rare.

Religious differences occasionally give rise to difficulties as for instance in parts of Egypt where Moslem and Coptic landowners dwell in the same village and their holdings are intermixed. In the past separate land registers had been compiled for those of each religion, and at first there was some opposition to all holdings being recorded in a single register.

There is no royal road to success in Cadastral Surveying, but the local conditions must be carefully studied, plans must be fully mapped out so that the work is started on a full and definite procedure; the area undertaken in the first instance may be as small as staff, funds, and experience demand, but whatever it be the work should be planned and carried out thoroughly, the permissible errors not being exceeded, marks being fixed and recorded, and all done with a view to the ready and effective revision of any portion at any subsequent time.

SEA ENCROACHMENT, FORT RICASOLI, MALTA.

By CAPT. C. W. BIGGS, R.E.

FORT RICASOLI is situated on a narrow peninsula of rock approximately 50 ft. to 60 ft. high, and about half-way along it there is a distinct fault in the rock which goes apparently right across from the sea to the harbour side.

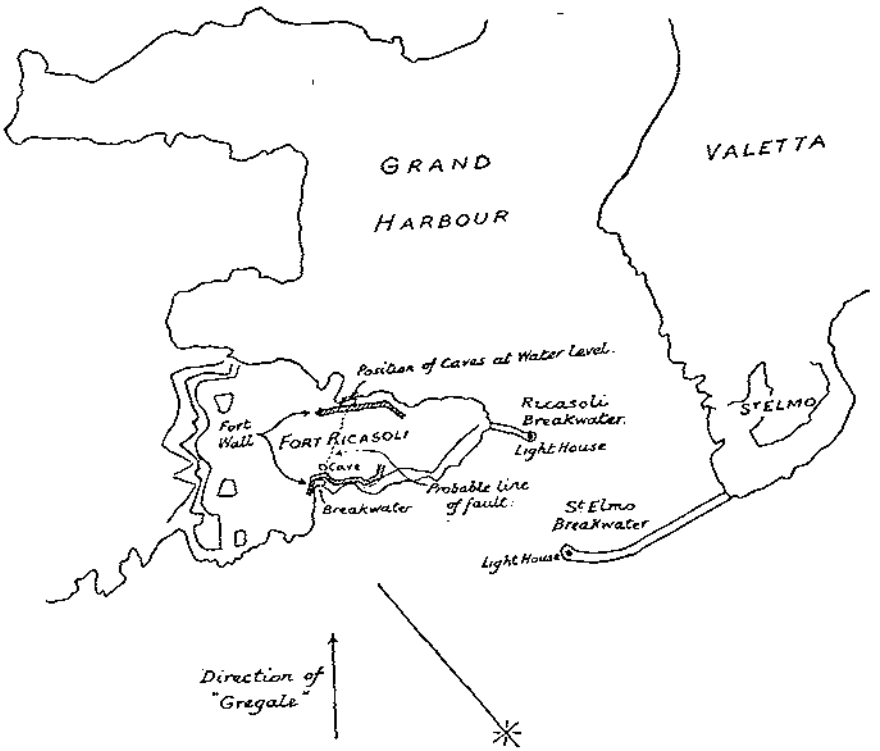
On the harbour side there are a number of caves at water level which are known to run for some considerable distance into the rock, and there are fissures in the rock above. No heavy seas are, however, experienced on this side, so that no real damage has been done. On the seaward side the effect of the sea on the fault has been considerable. The trace of the bastion walls, built by the Knights of Malta in about 1670, shows that even at that date an inlet on the line of the fault existed. This inlet faces north-east, and is thus exposed to the worst seas that come up with a "gregale," and the fault on this side is from 15 ft. to 20 ft. wide, filled with loose rock and clay formation. It can be clearly seen in the photographs.

The winter storms have gradually eaten into the fault, washing out the loose material and breaking off pieces of the rock on either side, and burrowed a regular tunnel under the parade ground. In about 1888, according to local information, a small hole about the size of a penny at first appeared in the parade ground about 100 ft. behind the bastion wall, and during a "gregale" a regular jet of water used to spout up through it. This, and the shock of the waves pouring into the tunnel, had the effect of enlarging this hole in the parade ground, until it is now some 30 ft. in diameter at the top and considerably more below. A fence was erected round it in 1890 or 1891, and it is known as "the Cave."

The tunnel which is now about 10 ft. to 12 ft. wide and 7 ft. high was walled up at the entrance and the cave was filled up two or three times, but the wall was broken down and the filling, with the exception of some three or four old 25-ton guns, was washed out. The entrance to the tunnel and the remains of the wall can be seen in the photographs, which also show the fence on the parade ground round the cave.

As the inlet became deeper it became more funnel shaped, so that the force of the waves breaking at its head increased, and the latter was finally so undercut that, during a storm on the night of the 31st March, 1906, a large portion of the parapet between the points AA (see *Plate*) fell into the sea. The only steps then taken were to erect a fence round the gap.

In 1908, one of the worst "gregales" experienced for a long time raged and further heavy falls of the cliff occurred. This "gregale," incidentally, also washed away practically all the heavy piles and staging, cranes, etc., in use by Messrs. Pearson on the St. Elmo Breakwater, then in course of construction, and the Ricasoli defence lights were run for several nights to assist Messrs. Pearson's men.



The safety of the rear portion of the Ricasoli Recreation Room and Billiard Room was now threatened; the rock face above the tunnel was so undercut that the waves broke right into the cavity so formed sending solid sheets of spray flying right over the parade ground, and the shock was so great that liquid was spilt out of glasses standing in the Billiard Room. The question of stopping any further encroachment by the sea was therefore taken up by the C.R.E.

One of the first proposals was to put up a reinforced concrete wall, taken down to solid rock level and well keyed on either side to the rock on the line BB (see *Plate*), and to fill up behind with stone. The estimated cost of this was £1,200 to £1,600. A detailed survey was carried out and a diver from the Dockyard employed excavating on the proposed site on the line of the fault; no solid rock was found, which showed that the fault went down vertically for some considerable distance.

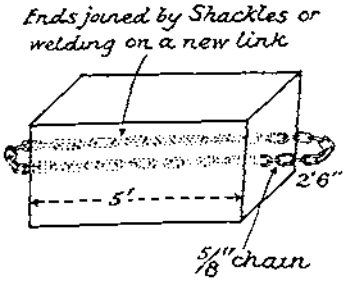
Messrs. Pearson's representative in Malta was asked to give his opinion on this proposal; it was to the effect that any wall erected would have to be at least as strong as the main breakwater of the harbour and would cost £10,000, the difficulty of providing a solid foundation being a serious item as nothing of this nature existed at a reasonable depth.

He recommended that a sort of breakwater should be made across the mouth of the inlet, by getting three large lighters, placing them in position (see *Plate*) raising their bulwarks and filling them with reinforced concrete till they sank, and in this way forming three large artificial rocks of about 900 tons each. The estimate for this was £4,000.

A third proposal was made by the C.R.E. viz., to make a breakwater of a number of small blocks 5 ft. × 4 ft. × 4 ft. or about 5 tons each, such as used in the Colombo Breakwater and in one at Osaka. The advantage of this proposal was that it could be carried out with local resources and added to as required.

This last proposal was approved by the War Office, and information was supplied of an Admiralty breakwater at Alderney which was formed of blocks, 5 ft. cube, chained together and piled in a rough mound. Details of the chain used were unfortunately not obtainable.

It was decided to make the blocks on the bastion just above the site chosen for the breakwater and then lower them into position. The blocks were to be of 6 to 1 concrete with the chain fixed through the centre, and were to set for two months before being moved. As the work was urgent and could not start until the chain was to hand, the latter had to be obtained locally, and after a strenuous hunt over the island, a quantity of good second-hand chain at a reasonable price was obtained. Some 80 blocks 5 ft. × 4 ft. × 4 ft. weighing about 5 tons each were made during January and February, 1910, at C (see *Plate*) and had lengths of chain fixed through their centres. 1-in. stud link chain in 10-ft. lengths was used for 30 blocks; the other 50 blocks had 20-ft. lengths of ⅝-in. close link chain (looped).



During these same months, a stone retaining wall founded on the solid rock, with a 4 ft. × 3 ft. concrete foundation, was built

round the top of the gap about 10 ft. back from the edge, and the iron fence was refixed on top of it. Where this wall crossed the fault, the concrete base was reinforced for a length of about 30 ft. with small iron rails.

In order to reduce the weight on the overhanging edge, the ends of the parapet walls were taken down for a length of about 5 ft. and practically all the loose earth (average depth about 3 ft.) in front of the new retaining wall was removed and thrown into the sea.

The cost of the work in 1909–10 was £502.

The blocks were lowered into position and the chains shackled together in April and May, 1910. A cable was stretched across between the bastion walls, over the site of the breakwater, and the blocks run out along this and lowered into position; the shackling being done by divers. On the left of the gap some large rocks formed, to a certain extent, a sort of natural breakwater, and amongst these the blocks were laid anyhow. Across the rest of the gap, they were laid in a 3.2.1 formation vertically, and the chains shackled together both vertically and horizontally. Strong seas were experienced in July, 1910, and the whole breakwater settled down: several blocks out of the upper row were however removed altogether, and a weak place appeared in the centre. Extra blocks were made in position during September, to strengthen this.

Total cost of work in 1910–11, £450.

During the winter of 1910–11, fairly heavy seas were experienced and the top layer of blocks disappeared below sea level as time went on. The remainder however prevented any waves from breaking against the undercut back wall and doing any further damage.

When the breakwater could be closely inspected from a boat in May, 1911, it was found that a large number of blocks had been washed out to the front, chiefly from the top two rows in the centre, and that the rest of the blocks had sunk a foot or so into the sand and taken a bearing in the soft bottom. Further work was imperative, and it was proposed to make 20 more blocks of a much larger size in position on top of the existing blocks and chain them together as before, but with much stronger chain.

On reference being made to the War Office some very important suggestions were made; the main points being that the blocks originally used were too small and blocks up to 40 tons should be used, any concave surfaces or re-entering angles in the face should be avoided; also that the blocks should be backed with a bank of large stones to counteract the effect of the backwash. As the entrance to the inlet was narrow and restricted by sunken rocks, it was decided that the blocks could not be made elsewhere, allowed to set, and then brought to the site or launched off lighters, and so the original proposal to make the blocks in position was adopted.

Access to the breakwater was got by descending into the cave and going out through the tunnel, but as the existing blocks were now all below sea level, it was necessary to build up a temporary platform at about sea level, on which to make the new blocks. Advantage was taken of the necessity to take down a large portion of an old bastion wall outside Fort Ricasoli which was in a dangerous state, and the material from this, mainly large stones, was brought into the fort, a bay of fencing removed, and the stuff dumped down behind the breakwater. This work took the whole of August (cost £74) so that the making of the blocks did not start till September, which, as experience showed, was rather too late in the year.

The work was carried out by direct labour. A platform of the large stones and empty cement barrels, filled with rough concrete, was constructed on the top of the existing blocks. The first of the new blocks made were 15 tons each, and as soon as they had set for three or four days they were launched off the platform to the front by means of jacks, thus adding to the depth (front and rear) of the breakwater. As experience was gained the blocks were made larger and the last ones were 10 ft. × 10 ft. × 6 ft. or 37 tons each. The work was constantly interfered with by rough weather, which not only washed away the temporary platform but broke up some of the blocks which had not had sufficient time to set.

The numbers of blocks made were as under :—

6 of 10 tons each, of which 4 were launched to the front and 1 destroyed.
9 of 15 tons each, of which 7 were launched to the front and 1 destroyed.
2 of 18 tons each, of which 1 was destroyed.
3 of 22 tons each, of which 2 were launched to the front and 1 destroyed.
6 of 37 tons each, of which 1 was launched to the front and 2 destroyed.

These were chained together by means of ¾-in. and ⅞-in. chain, obtained from the dockyard at a nominal cost and placed through the blocks during construction, and by the shackles left over from the previous year.

In addition, an experiment was tried with a lighter ; an old one was bought for £16 10s. (including anchor and chain) and anchored close in front of the centre of the breakwater. It would have held from 90 to 100 tons, but most unfortunately the sea got up soon after the work of filling it was started and although work was carried on for two nights up to 12 m.n. it was sunk when only about half full. The restricted conditions under which the work was carried on made it much slower than was anticipated, and the rough sea at the very beginning of September was unusual. Even though only

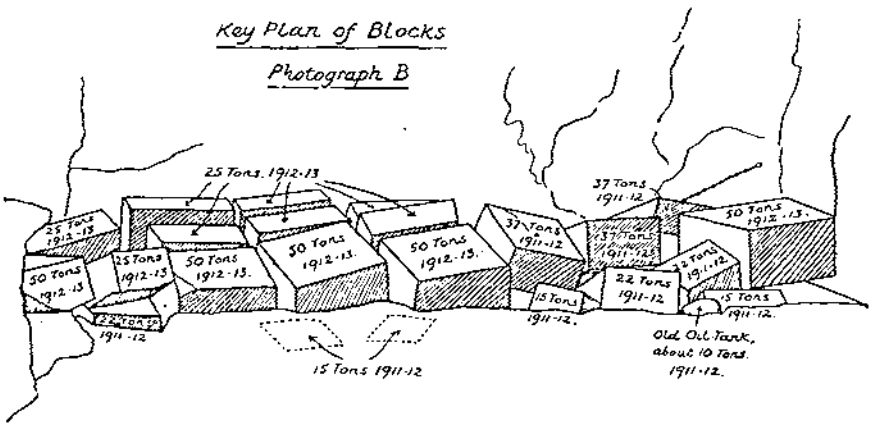
half full there is no doubt that this large block in front of the breakwater has helped to prevent the smaller ones from being washed out.

The winter seas, as was expected, washed away the temporary platform and all the blocks settled down. The result was however quite satisfactory, as on the left, where the large rocks under water were, a really substantial breakwater had been formed extending about half-way across, and on the right the blocks had got well settled in position. The centre however had suffered rather severely. All the blocks that were moved had been moved in towards the cave and not outwards as before, and, in addition, all the small stuff used in the temporary platform had been piled up into a bank at the mouth of the cave, so that the sea now was helping to defeat itself.

Cost of the work this year, 1911–1912, was £400.

In 1912–1913 the work done was practically a continuation of the previous year's, only the blocks made were of 50 tons each, viz., 12 ft. × 12 ft. × 6 ft., and were left when made. Each one was completed in a day, and is about the largest which can be made on this site without resorting to all-night work and consequently double working parties. Five of these 50-ton blocks were made, three in the centre and one in each angle at the side, and as a backing six 25-ton blocks were made later on behind those in the centre. Rough weather, however, was experienced soon after the work was completed, and two of the 25-ton blocks had not set properly and were broken up. In spite of its backing the centre 50-ton block was forced back some 10 ft. to 12 ft.

Cost this year, £185.



The accompanying photographs A, B and D show the work as completed in September, 1912, and C shows its condition in April, 1913. It will be noticed that even in September the temporary platform had been slightly washed away and that the centre blocks were settling down. The big block on the left-hand side (right in

SEA ENCROACHMENT, FORT RICASOLI, MALTA.

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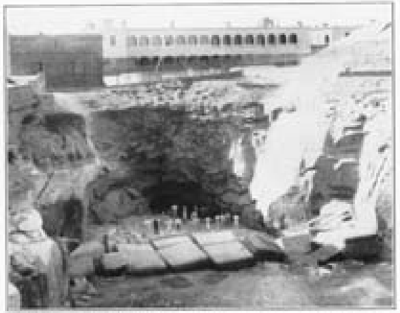

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SEA ENCROACHMENT, FORT RICASOLI, MALTA.

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FORT RICASOLI, MALTA

the photos) was moved slightly as shown by the mark on the cliff, but otherwise no movement at all took place on this side; on the right (left in photos) the blocks have been forced well back against the cliff, which is much undercut just here, and are now wedged well in, and should not be moved much more. The centre 50-ton block has suffered rather from a smaller and older block just in front which has eaten into it and made a cavity about 2 ft. diameter, and 1 ft. deep. The small material from behind the blocks has been piled up into the mouth of the tunnel. On the right of the photograph C there is a scar on the cliff face, showing where a piece of the cliff was broken away during the winter.

Summary.

Now that the action of the sea tends to force the blocks inwards instead of washing them out, it would seem that a satisfactory solution of the problem has been found and all that will be necessary on this site in the future will be the addition of these large blocks from time to time as found necessary, and the continued filling in behind them.

The results of the work here appear to prove that, in addition to the requirements laid down in the War Office letter of July, 1911, the breakwater required greater depth from front to rear, so as to have a much flatter slope in front.

An attempt to produce this flatter slope was made in 1911–1912, when a large number of blocks were made on the breakwater and then tipped forward to the front; the waves are also now helping by forcing the top blocks inwards and in course of time a breakwater with an outer face at an approximate slope of about 1 over 2 will probably be formed which should then require very little extra maintenance.

With regard to the actual work done, I think that the method adopted at the start was the only possible one which could have been carried out with local resources unless lighters had been used. Although the chain used was apparently not strong enough, and in consequence such a large number of the blocks were washed out to the front, still they made a foundation on which it was possible to make the blocks *in situ* the following year and also incidentally started to give the extra depth required.

Any additional blocks made in future should be of really good concrete and reinforced. I suggest 4 to 1 or even 3 to 1, and I consider that all external faces should have all air holes, etc., carefully stopped up. Care should be taken that the reinforcement is so placed that it is not likely to become exposed, as if this happens the action of the rust will probably tend to split the blocks.

The existing blocks were made on the loose top of the temporary

platform and the bottoms are consequently rough and irregular. This was done to save the cost of the timber base which could not have been recovered if it had been used, but it was a mistake as it gave the waves something to bite into.

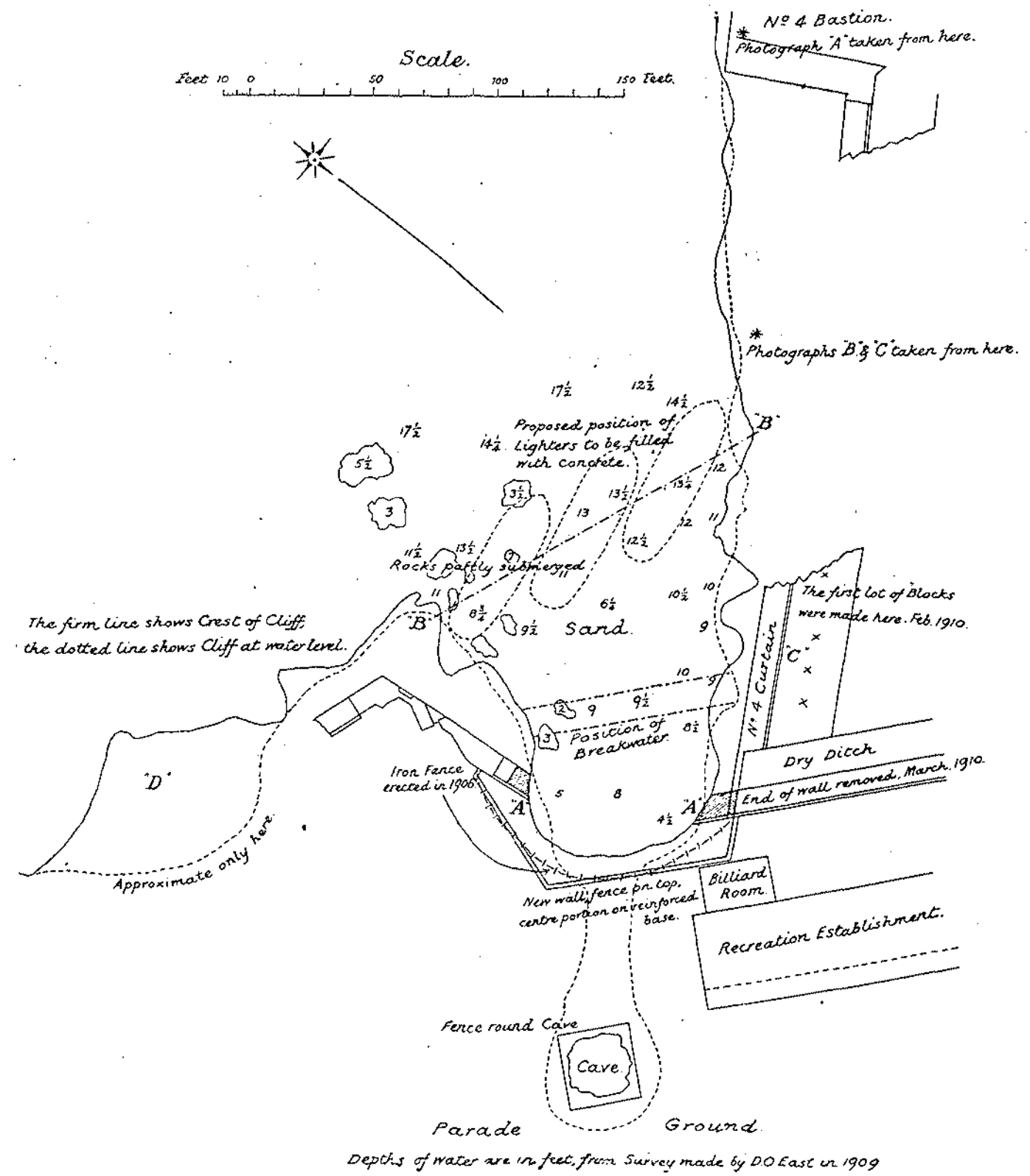
If chain is used it should, I think, be really heavy anchor chain, as the power exerted by the waves can be so enormous.

SUMMARY OF EXPENDITURE.

	£ s. d.	£ s. d.
1909–1910.		
Survey work, hire of boats		6 10 0
Diver		1 6 0
Removing earth from edge, and building retaining wall, and refixing fence :—		
Labour and material ..	172 0 0	
Cement	34 0 0	
		206 0 0
Making blocks, 5 tons, and fixing chains :—		
Labour, casing, spalls, etc. ..	99 0 0	
Cement	136 0 0	
		235 0 0
Purchase of chain and shackles		53 0 0
		£501 16 0
1910–1911.		
Lowering and shackling blocks		368 0 0
Extra work		56 0 0
Cement		25 0 0
		£449 0 0
1911–1912.		
Filling in behind breakwater with débris from bastion wall outside the fort		74 0 0
Purchase of lighter		16 10 0
Purchase of chain		1 10 0
Cement		*113 0 0
Labour on loading		3 10 0
Labour, watchman, casing, spalls, etc.		192 0 0
		£400 0 0
1912–1913.		
Cement		24 0 0
Labour, watchman, casing, etc.		161 0 0
		£185 0 0
Grand total .. £1,536 0 0		

* Includes £30 10s. for cement ordered for use in 1912–13.

SEA ENCROACHMENT, FORT RICASOLI, MALTA.



SIEGES AND THE DEFENCE OF FORTIFIED PLACES BY THE BRITISH AND INDIAN ARMIES IN THE XIXth CENTURY.

(*Continued*).

By COLONEL SIR EDWARD T. THACKERAY, V.C., K.C.B. (LATE R.E.).

DESCRIPTION OF THE LINES OF TORRES VEDRAS.

With Graham's departure from Cadiz, the principal interest in the defence ceases, and although the siege dragged on till 1812, it ultimately proved unsuccessful.

In the present number it is proposed to deal with the Lines of Torres Vedras, which are referred to by Sir J. T. Jones in his *Sieges in Spain* as "a triumph of the British Nation."

The idea of fortifying the hills round Lisbon seems to have first occurred to the Duke of Wellington towards the end of 1809, when he realized how untenable was his position at Badajoz, and how necessary it would be for him to devise some different means of defence to enable him to resist the overwhelming masses which he foresaw would shortly be hurled against him by Napoleon. In his memorandum to Sir R. Fletcher dated October 20th, 1809, he commences with a clear summing up of the situation, and then instructs Colonel Fletcher to examine and report upon the defensive capabilities of the position under 21 separate headings. As Sir R. Fletcher's report confirmed Wellington's opinion, work was at once commenced upon the Lines, and was continued without a break right up to the time when the British Army, closely pursued by the French, entered the outer line of defence on the 8th of October, 1810.

The position thus fortified consisted of three distinct lines of defence.

The first extending from Alhandra on the Tagus to the mouth of the Zizandre on the sea coast, was, following the inflection of the hills 29 miles long.

The second traced at a distance varying from 6 to 10 miles, in rear of the first, stretched from Quintella on the Tagus to the mouth of the St. Lorenza, being 24 miles in length.

The third intended to cover a forced embarkation, extended from Passo d'Arcos on the Tagus to the tower of Junguera on the coast. Here an outward line, constructed in an opening of 3,000 yards, enclosed an entrenched camp, the latter being designed to cover an

embarkation with fewer troops if such an operation should be delayed by bad weather. This second camp enclosed Fort St. Julian whose high ramparts and deep ditches defied an escalade, and were armed to enable a rear guard to resist any force. From Passo d'Arcos to the nearest part of the second line was 24 miles; from the first line it was two marches, but the principal routes lay through Lisbon, where means to retard the enemy were prepared.

Of these stupendous lines the second, whether for strength or importance, was the principal; the other two were subsidiary—the third being a mere place of refuge. The first line was originally designed as an advanced work, to stem the primary violence of the enemy, and to enable the army to take up its ground on the second line without hurry or pressure; but, while Massena remained inactive on the frontier, it acquired strength which was so much augmented by the rain, that Wellington resolved to abide the attack there permanently.

It offered five distinct positions from right to left as follows:—

1st. From Alhandra to the head of the valley of Calandrix. This portion 5 miles long was a continuous and lofty ridge defended by 13 redoubts, and for 2 miles was rendered inaccessible by a scarp 15 to 20 ft. high. It was guarded by Hill's Corps, and flanked from the Tagus by a flotilla of gunboats manned by British seamen.

2nd. From the head of the valley of Calandrix to the Pé de Monte. This portion also of 5 miles, presented two salient mountains forming the valley of Aruda, that town being exactly in the mouth of the pass. Only three feeble redoubts incapable of stopping an enemy were constructed here, and the defence was entrusted to the light division.

3rd. The Monte Agraça. This lofty mountain overtopped the adjacent country, and from its summit the whole of the first line could be seen. The right was separated from the Aruda position by a deep and blind ravine; the left overlooked the village and valley of Zibriera; the centre overhung the town of Sobral: the summit was crowned by an immense redoubt armed with 25 guns, round which three smaller works armed with 19 guns were clustered. The garrisons amounting to 2,000 men were supplied by Pack's Brigade; and on the reverse slope about 4 miles in length, Leith was posted in reserve.

4th. From the valley of Zibriera to Torres Vedras. This portion 7 miles long was at first without works, because it was only when the rains had set in that the resolution to defend the first line permanently was adopted. But the ground, rough and well defined, having a deep valley in front watered by the Zizandre now a considerable river, presented a fine field of battle.

Here Spenser and Cole, reinforced with a sixth division formed of troops recently come from England and Cadiz, were stationed under

the immediate command of Wellington, whose quarters were fixed at Pero Negro, just under the lofty Secora Rock, on which a telegraph was erected to communicate with every part of the line.

5th. From the heights of Torres Vedras to the mouth of the Zizandre, the right flank of this portion and a pass in front of the town of Torres Vedras were secured by a great redoubt mounting 40 guns, and by smaller forts judiciously planted so as to command all the approaches. From these works to the sea a range of moderate heights was crowned with minor redoubts; but the chief defence there, after the rains had set in, was to be found in the Zizandre, unfordable and overflowing so as to form an impassable marsh. Such were the defences of the first line, strong, but at several points defective; and there was a paved road, running parallel to the foot of the hills through Torres Vedras, Sobral and Aruda to Alhandra, which gave the enemy an advantage.

The second and most formidable line also will be described from left to right.

1st. From the mouth of the St. Loureñca to Mafra. In this distance of 7 miles there was a range of hills, naturally steep, artificially scarped, covered by a deep and in many parts impracticable ravine. The salient points were secured by forts which flanked and commanded the few accessible points; but the line was extensive and a secondary post was fortified a few miles in the rear so as to secure a road leading from Esceceria to Cintra.

2nd. The Tapadas or Royal Park of Mafra. Here there was some open but strong ground, which with the Pass of Mafra was defended by a system of 14 redoubts constructed with great labour and care, well considered with respect to the natural features, and in some degree connected with the above-mentioned secondary post: the Sierra de Chypre, covered with redoubts, was in front and obstructed all approaches to Mafra itself.

3rd. From the Tapadas to the Pass of Bucellas. In this space of 10 or 12 miles forming the middle of the second line, the country is choked by the Monte Chique, the head of which is in the centre of, and overtops all the other mountain masses. A road conducted along a chain of hills, high and salient through less bold than any other part of the line, connected Mafra with the Cabeça, and was secured by a number of forts. The country in front was exceedingly difficult, and behind was a parallel and stronger ridge which could only be approached with artillery by the connecting road in front; but to reach that, the Sierra de Chypre on the left, or the defile of the Cabeça must have been carried. Now the latter was covered by a cluster of redoubts constructed on some inferior rocky heads in advance; they commanded all the approaches, and from their artificial and natural strength were nearly impregnable. The Cabeça itself and its immediate flanks were secure in their natural

precipitous strength; so likewise were the ridges connecting the Cabeça with the Pass of Bucellas, wherefore, save the blocking of one mule path they were untouched.

4th. From Bucellas to the low ground about the Tagus. The defile of Bucellas, rugged and narrow, was defended by redoubts on each side, and a ridge, or rather a collection of impassable rocks, called the Sierra de Serves, stretched to the right of it for 2 miles without a break, and then died away by a succession of ridges into the low ground on the bank of the Tagus. These declivities and the flat bank of the river offered an accessible opening, $2\frac{1}{2}$ miles wide. It was laboriously defended indeed by redoubts, water-cuts, retrenchments, and was carefully connected with the heights of Alhandra; yet it was the weakest part of the line, and dangerous from its proximity to the valleys of Calandrix and Aruda.

Five roads, practicable for guns, pierced the first line of defence; two at Torres Vedras, two at Sobral, one at Alhandra; but as two of these united again at the Cabeça, there were only four points of passage through the second line. Hence the aim and scope were to bar these roads, and strengthen the favourable fighting positions between them without impeding the movements of the army; the loss of the first line therefore would not have been injurious, save in reputation, because the retreat was secure upon the second and stronger line; moreover the guns of the first line were all of inferior calibre, mounted on common truck carriages, immovable and useless to the enemy. The allies' movements were quite unfettered by the works, but those of the French Army were impeded by the Monte Junta, which rising opposite to the centre of the first line, threw out a spur, called the Sierra de Baraqueda, in a slanting direction towards the Torres Vedras Mountain, and only separated from it by the Pass of Ruña, which was commanded by heavy redoubts. Massena had therefore to dispose his army on one or the other side of the Baraqueda which could not be easily passed; nor could a movement over it be hidden from the allies on the Monte Agraça, who from thence could pour down simultaneously on the head and tail of the passing columns with the utmost rapidity, because convenient roads had been previously prepared, and telegraphs established for the transmission of orders.

Such were the lines which, in the words of Sir John Jones, "are without doubt the finest specimen of a fortified position ever effected. Every objection heretofore urged against lines fail in application to those. From their peninsular situation there is no possibility of manœuvring on the flanks, cutting off the supplies, or getting in rear of them: in the details of the work there is no pedantry of science; no long lines of fortification for them without strength; mountains themselves are made the prominent points; the gorges alone derive their total strength from retrenchments. The quantity of labour be-

stowed on them is incredible, but in no part has the Engineer done more than his duty ; assisted nature, assisted the general, and assisted the troops, and for each arm has procured a favourable field of action. For the militia there are nearly unattackable posts to guard the passes ; for the infantry, admirable fields of battle, suited to ensure and to profit by victory ; for the cavalry, spacious plains to which the enemy must arrive through passes rendered impracticable to their cavalry and artillery. No movement either forward or lateral is cramped ; on the contrary, one chief beauty of these lines is the facility afforded to communication : by a system of judicious and well-planned roads, the distance between each point and each corps of troops has been one-half shortened ; and from the precaution of having these roads commanded by works not to be reduced without artillery, they become useless to an enemy in case of accident or partial success ; and on the great scale, Nature has contributed much to this object by placing Monte Junta immediately in front of the centre of the line, the ramifications of which, extending to the very works, render the enemy's movements in front of the lines tedious and difficult, and give to a body of troops posted within, a superiority of movement rendering them equal to twice the numbers without."

These celebrated lines were great in conception and execution, more in keeping with ancient than modern military labours ; and it is clear that the defence was not dependent, as some French writers suppose, upon the first line. If that had been stormed the standard of Portuguese independence would still have floated securely amidst the rocks of the second line. But to occupy 50 miles of fortification, to man 150 forts, and work 600 guns, required many men, and numbers were not wanting. A great fleet in the Tagus, a superb body of Marines sent out from England, the civic guards of Lisbon, the Portuguese heavy artillery corps, the Militia and ordnance of Estremadura, furnished a powerful reserve to the Regular Army. The Native gunners and the Militia supplied all the garrisons of the forts on the second, and most of those on the first line ; the British Marines occupied the third line ; the Navy manned the gunboats on the river, and aided in various ways the operations in the field. The recruits from the depôts, and the calling in of all the men on furlough, rendered the Portuguese Army stronger than it had yet been, while the British troops reinforced from Cadiz and England, and remarkably healthy, presented such a front as a general would desire to see in a dangerous crisis.

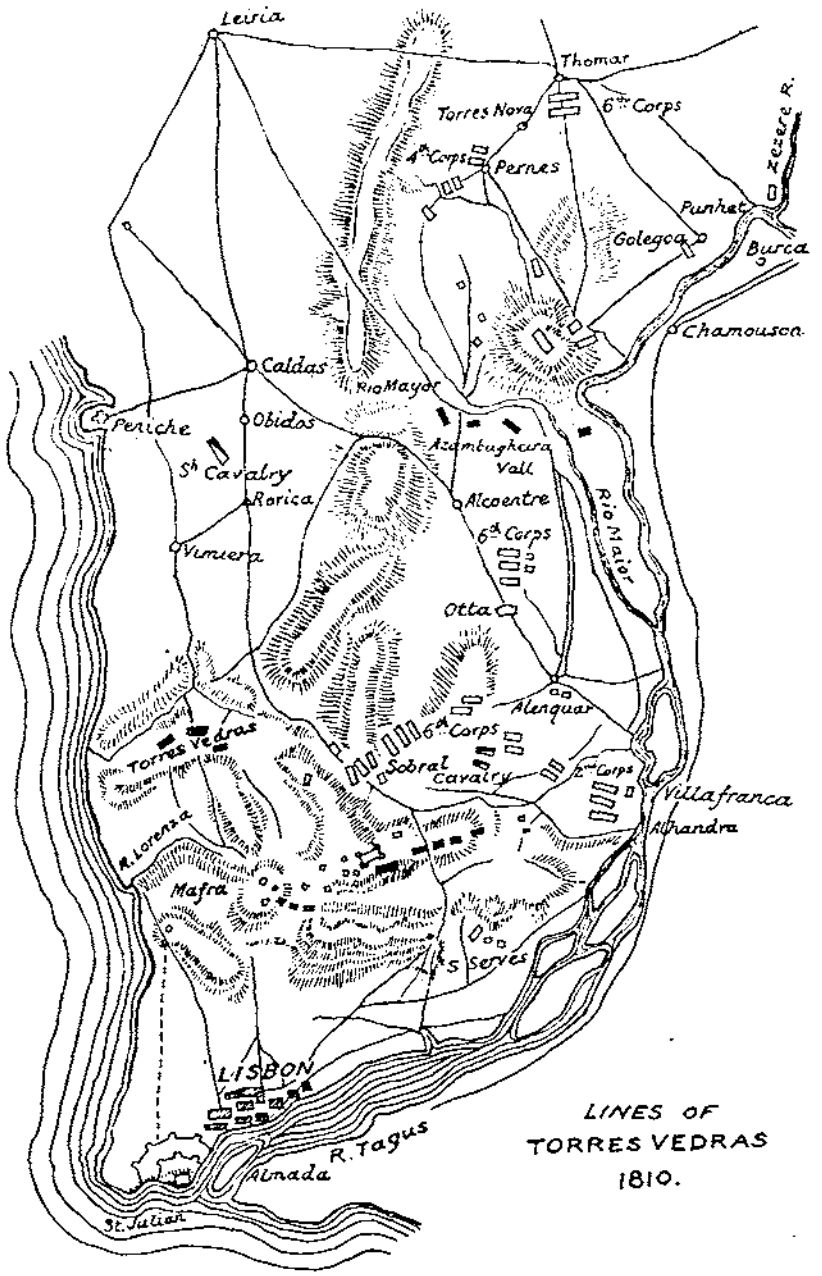
It was however necessary to have the appearance of even greater strength, and Wellington therefore arranged with Romana, that without much attention to the wishes of his own government, he should join the allies with 6,000 men. Fortune aided the English general's efforts to increase the distance between Massena and Soult, and to diversify their objects at the moment he had concentrated the

greatest force at the most important point; for before September more than 120,000 men were rationed within the lines, 70,000 being Regular troops.

Massena was surprised at the extent and strength of works which he had only heard of five days before, and it is scarcely necessary to dwell upon the remarkable way in which they achieved their object, nor to show how they practically proved to be the turning point in the Peninsular War. The French Army when it arrived before them numbered over 50,000 men flushed with victory, and although this force was further reinforced by another 10,000, Sir John Jones estimates that only some 40,000 men were left when Massena on the 5th of March determined to retire out of Portugal so as to save his army from complete destruction. Even then, although he conducted his retreat in a masterly manner, his broken, starving troops were in no way a match for their victorious adversaries. For one month Lord Wellington constantly harassed his retreating troops allowing them no respite, until he finally drove them over the frontiers in a state of sickness and misery which ultimately destroyed more of them than any partial action could have done. No decisive action was fought during this pursuit, as in Wellington's own words he preferred "to harass them and send them out of the country as a rabble when from want of organization and from sickness, they will not be able to act for many months, and to keep my own army entire, rather than to weaken myself by fighting them, and probably be so crippled, as not to have the ascendant over fresh troops on the frontiers."

Finally, on the 5th of April the French Army recrossed the Spanish frontier, and Wellington halting his troops at Alfaiates gave up the pursuit.

(To be continued).


Leiria
Thomar
Torres Nova
6th Corps
Zezere R.
4th Corps
Pernes
Punhete
Golegoa
Burca
Chamousca
Caldas
Rio Mayor
Peniche
Obidos
Azambuja
Vall
5th Cavalry
Rorica
Alcoentre
Rio Maior
6th Corps
Vimiera
Otta
Alenquer
Torres Vedras
6th Corps
Sobral
Cavalry
2nd Corps
Villafranca
Alhandra
R. Lorenza
Mafra
Serves
LISBON
R. Tagus
Almada
St. Julian
LINES OF
TORRES VEDRAS
1810.

A NARRATIVE OF THE SEVERAL TRANSACTIONS OF THE FRENCH IN THEIR ATTACK OF FORT ST. GEORGE, AND OF THE GARRISON IN THE DEFENCE OF THAT PLACE. ANNO 1758 AND 1759.

THE original manuscript of the following interesting account of the Siege of Fort St. George in 1758, has been presented to the R.E. Museum by Colonel C. F. Call, late R.E., and was written by his ancestor Mr. J. Call, the Chief Engineer during the Siege. In Cambridge's *Account of the War in India*, published in 1761, a large part of the diary was included but the opening comments were omitted. It is from this work that the accompanying map has been obtained, as it is missing from the manuscript.

It may be added that in the following account the original spelling and punctuation have been preserved throughout.

By Way of Introduction to the following Narrative of the Siege of Fort St. George I shall beg leave to make a few Remarks on the sudden Surrender of places lately besieged, and endever to vindicate the Art of fortifying from the unjust reflections cast thereon. I shall then show the Motives which induced Mr. Lally to form a regular Siege; and conclude with enumerating the advantages the besiegers generally have over the besieged.

The Superiority of Attack to Defence has seemingly been confirm'd by so many Instances within this last Century that it has almost establish'd a Maxim among Engineers as well as others. "That 'till some new System of Fortification is invented it is impos-"sible any Place can withstand above a few Days the rigorous "Method of attacking now in Use." And another "That a Place "besieged is lost." This I grant is apparently the Case; and the Number of places taken have given great Room for Experience and Improvement in the Art of Attack while in the additions made to old Enceintes in the few Places lately built the Engineers of that Class have been confin'd to an old Plan, or those Systems establish'd by the great Names of Coehorn and Vauban beyond the Authority of Modern Artists. But if we look farther (tho' I allow and shall prove that besiegers have great advantages) it will perhaps appear that very few Places have had Justice done them in the Defence: To discover this we need only cast an Eye over the Plans of Places (many of which were famous for the Strength of their Fortifications)

taken with a rapidity scarce to be imagin'd in the last War. It will from thence appear that most of them were surrended by a Capitulation and that too before the breaching Batterys were constructed; others in which a breach was made, never stood an Assault, except Bergen op Zoom; and it is confidently reported there was either Treachery, or to say no Worse an unpardonable neglect in the Disposition of the Troops for the Defence. How then can the blame be thrown on the Works which are but secondary Means of Preservation, and have seldom or never of late, been made use of to extremitys. 3rdIf Policy to preserve the Effects and Priveleges of the Inhabitants of a Town, or to prevent that often threatened butchery the consequence of a Place taken by Assault; or lastly if preserving the Liberty of so many Troops to a State; I say if these are admitted as sufficient Motives for surrendering a Place still the Works are not to be blam'd. But if instead of these Considerations a mere pageant Form of Military Honors in the Manner of losing a Town, has any weight; and if it is admitted as a Point of Consequence to obtain leave for the Governor at the head of his Garrison to march as far as the covered-way and there surrender Prisoners, I say if this is sufficient to save the credit of an Officer who wou'd defend a breach at the hazard of his Life and Fortune when so fair an opening is given him to save both? And how easy then is the Fate of a Place determin'd when the Commanding officer of both Partys aims nearly at the same End; the one to gain honor by making a breach, and the other to save his 'till a breach authorizes a Surrender. 4thNot such was the Behavior nor such the Motives of the Governor and Garrison of Fort St. George; the consequences too were different, and it has been prov'd by a conviction glorious for them, that an heap of Earth may be defended when an honest Resolution animates the Defendants. Shou'd it be urg'd that the Fortifications of Fort St. George were too formidable and the Garrison too numerous to be attack'd with any View of Success by so small a Force as Lt. General Lally commanded before it; I shall allow that as these Matters are usually considered it had the appearance of a vast Undertaking. But to state the Matter clearly let us take a View of the Motives which encouraged the Attempt; and it will appear in the Course of that Consideration, that the Disposition of the Garrison and appearance of an obstinate Resistance to the last extremity, intimidated the Enemy, and prov'd a greater Security to us than cou'd be imputed from the ruinous Condition of our Works. 5th The View of the French Nation in sending out at an immense Expence such a Number of considerable officers and so large a Force as Lt. General Lally brought with him cou'd be nothing less than the entire destruct. of the English possessions in the East Indies. Mr. Lally soon recd. encouraging earnest of Success in the easy Reduction of Fort St. David, the reputed Barrier to his Conquests, and he no

doubt wou'd have pursued his blow by attacking Fort St. George even in the hottest Weather, had he not been aw'd by the presence of our Fleet. The removal of that obstacle to Bombay and the junction of the French Forces from the Decan, having furnish'd an opportunity of pursuing his Projects, he took the necessary previous Steps in October. He well knew that we never shou'd be weaker than at that Juncture, and he had soon after the satisfaction to hear that our expected Succors were on the Malabar Coast, and consequently coud not be with us till late in Janry. Notwithstanding this Mr. Lally did not perhaps at first intend a regular Siege but on weighing well the Strength of his Situation in the black Town, the convenience of a strong Post at St. Thomé, and the advantages to be drawn from the proximity of the houses to the Glacis of the Fort, he had some reason to think it might be possible for 3,500 Europeans to carry on Approaches against Fort St. George tho defended by more than 1,500. In this too he was the more confirm'd by the lucky Arrival of the *Haarlem*, which Ship he had providentially sent to Mazulipatam in October with battering Cannon; and by the easy Conveyance for Most of the heavy Stores from Pondichery by Sea. Thence many of the Inconveniencys apprehended from leaving Chinglaputt in our Possession, and from the black Army which he knew we expected from Tirichnopoly, were in great measure remov'd; and Mr. Lally found himself in a Condition to erect Batterys against the North Front which he determind to attack by advancing along the sea side, and breaching the Demy Bastion. This appear'd to him the easiest approach and the weakest part of the Town, in which opinion many of the Defendants concurr'd, but for my part I always thought the contrary, notwithstanding the facility of advancing where our flank is covered by the sea. However this is not material, he knew that the Fortifications were chiefly temporary, and these incompleat, he also knew the Town was pretty large and not wholly secure against a Coup de Main; that the Garrison tho' numerous with respect to the Assailants must therefore be attentive to every part, and that the Duty must consequently be very hard, or but few Men posted on the front attack. All these Circumstances were really true but I am persuaded he was farther actuated by the easy conquest of Fort St. David which every one deem'd stronger than Fort St. George, and the mean opinion he conceiv'd from thence of our Military Force directed by a Council of Merchants; whom from their opposite Professions to War, and apprehensions for their possessions and Effects, he imagin'd wou'd soon incline to a favorable Capitulation. But how was he here mistaken! This Council of Merchants so much despis'd had provided every thing necessary for a long Siege, and by the regular distribution of the several Employs among themselves and others aided by the great activity and exemplary Encouragement of their Honble

President, it is allow'd no place was every better supply'd or more cleanly kept. Nor did ever Garrison bear with greater resignation the hardships of a Siege, or Inhabitants behold with less uneasiness the destruction of their houses and Effects. Thence it arose that no thoughts were entertain'd of a Capitulation, and that the general discourse even of the common Soldiers turn'd on the Defence of the breach and the Slaughter they wou'd make if the Enemy attempted an assault.

Of this Mr. Lally was long ignorant and encourag'd by our cautious Defence ; he flattered himself if he cou'd once gain the covered Way, the Affair wou'd soon Terminate : He therefore advanc'd by a very paltry kind of flying Sap and Crochets to the top of the Glacis, without any great loss ; where a breaching Battery was establish'd against the Demy and North East Bastion without regarding the North Ravelin or the Orillon Flank of the Royal which defended the Bastion attacked with 6 Guns. In this Mr. Lally propos'd to follow the Method he had seen practis'd by Marshall Lowendalh at Bergen Op Zoom, but he soon found he had a Garrison differently dispos'd to deal with ; and tho' he added the Terror of a Mine to that of his Battery, he perceiv'd no Signs of a Capitulation. On the contrary his Battery was soon silenc'd, Numbers of his Men daily destroyed, and preparations making to blow up both if they had continued longer ; He therefore began to fire again from his grand Battery without trying the effect of a threatening Summons ; and after unsuccessful attempt to push on by the Sea, he was so thoroughly convinc'd of our steadiness, and the obstinate resistance he shoud meet with that he prudently resolv'd to retire.

Thus have we describ'd Mr. Lallys pressing Motives for attacking Fort St. George, and his method of proceeding therein ; from whence it has been seen how 3500 Europns. regularly besieged near 1600, tho' frequently oblig'd to make large Detachments and undergo severe Skirmishes with our black Army. Nothing I imagine but the critical conjunction of Time, the absolute necessity of possessing Fort St. George before he cou'd execute the remainder of his Plan, and the vast advantages which wou'd have follow'd such a Conquest, cou'd have induced Mr. Lally to undertake a Siege with forces so far short of the usual Proportion between the besiegers and the besieged : But if every disadvantage of the Defendants be consider'd, I think it will in general appear that the assailants have the fairest chance of carrying their Point ; and I am sure I can prove in our own Case, that the Enemy to the last had men sufficient to make an assault had things been brought to a proper Crisis.

In every Place besieged whatever Care has been previously taken a thousand things must still be done when the Place is invested and the Front to be attack'd discovered ; These bring hard Duty on the Garrison which added to offensive Smells, want of many little

necessarys and a confin'd Air soon occasion extraordinary sickness among the Soldiers, especially when there is a want of secure Places to rest in, and no Inhabitants or Laborers to ease them of working Duty. The daily destruction among the Troops the ruins of the Works and houses, and the constant appearance of the Enemys advance, seconded by reflections that every place lately besieged was taken certainly introduces a share of despondence among the most resolute Garrisons. On the contrary the besiegers have every thing to encourage them: First plunder of the Suburbs; then hopes of plundering the Town; the Liberty of roving at Pleasure the Plenty of Provisions; the constant destruction they behold of some object by every shot and shell they fire; and lastly their daily advances and the Garrisons retreat, are so many Inducements for them to prosecute that Labor, and undergo the fatigues which are to compleat their Wishes.

I do not pretend to say what I have described was exactly the Case with the besiegers or the defendants of Fort St. George, but I am persuaded it happens in almost every other place; and I also know that after the Sally of the 14th we had only 1377 effective Troopers, Artillery and Military, of which 100 were constantly employ'd as Pioneers, and the Enemy had then 3300 men; By the middle of the Siege we were reduced to 1000, and before the End of it we had not full 800, so that granting 300 were on Duty every Day, still we cou'd not oppose 50 men in any Work of the North Front, and in most we had not half that Number. The Enemy had by Mr. Lallys own Letter 2000 effective Men the 14th Febry; Now had the breach been wholly practicable what advantage must the besiegers have had; who being masters of their Method and Time of Attack cou'd purposely have favor'd their men, and fallen on with vast superiority in three or four Places; while the Garrison equally attentive to all and unappriz'd of the Enemy's Intention must have fought with very unequal Numbers and cou'd hardly expect a support till the contest was decided? For my own part I sincerely wish we had three to one against Pondichery, or only 4500 men to attack Mr. Lally and 2000 French in it. I think the conquest wou'd be certain; expecially if we were once advanc'd to the Counterscarp, and our Cannon had breach'd the Walls. Not that I esteem the French bad Soldiers, on the contrary they ought from experience to be good ones, but I know the place is too large and too weak, to be defended against any reasonable force skilfully conducted.

I hope the example of the Garrison of Fort St. George will not long be singular, but that every British Town which shall be attack'd in future will be defended with the same laudable Resolution, and the Consequences be as valuable to the Nation as the preservation of Fort St. George has been to the East India Compy. On the Fate

of this Place their very Existence depended; for it is hardly to be doubted but Mr. Lally wou'd have push'd his Conquests to Bengall as soon as he had reduc'd the English Settlements on the Coast of Coromandel; and the Instant Monsr. D'Achér had been superior to Admiral Pocock, Bombay must have fallen. The same dismal scene of Destruction woud have follow'd each of these when conquered as has been practis'd at St. David, and Fortifications which have cost near a Million Sterling woud have been reduced to an heap of rubbish. These Consequences the Govr., the Council, and the principal officers in Fort St. George had thoroughly considered and instead of dreading the Danger that threatened them, they determin'd bravely to oppose that destruction which seem'd to threaten others, and resolv'd if possible to avert it at the expence of their Lives and Fortunes. A Resolution glorious in its nature! and worthy Emulation: And which his Majesty, the East India Company, and the whole Nation will doubtless reward with those distinguishing Marks of approbation due to such uncommon Zeal for their Service.

Before I enter on the Siege it may not be altogether improper to say a word or two of the Motions of the French Army previous to the Investiture of the Place. After General Lallys return from his unsuccessful expedition against Tanjore, he canton'd his Army in Gingi, Wandewash, and Chettaput: and sent a party to Carangoly which we had abandoned: We had done the same by Chinglaputt, but after the arrival of Colonel Draper, and part of the Battalion, it was garrison'd again, and resolved to be maintain'd. The Enemy about the latter End of October gave out, that they actually intended to besiege Madrass; but our expectations of the rest of the Battalion; the approach of the Monsoon; and the necessity we imagin'd they wou'd be under of first taking Chinglaputt; made us conclude they wou'd scarce be in a Condition to undertake such an enterprize; especially as we estimated our Garrison as equal to half their force. However we had certain advice of Cannon being put on board a Ship at Pondichery, and of Mortars, and other stores collecting at Carangoly. In the beginning of October the French moved to Arcott; took that place; and return'd soon after to Conjiveram, from whence they sent a Party up to dispossess us of Tripassore which being indefensible we abandoned to them. While the Enemy continued at Conjiveram they collected great quantitys of Ammunition, and other Stores, and were join'd by a body of 500 Men from the Army which Mr. Bussy had long commanded in the Golcondah Province—About the beginning of December Mr. Lally imagining the Monsoon at an End moved with the greater part of his force to [a] Trepermadore, and gave out that he wou'd invest

[a] A Village about half way between Madrass and Conjiveram.

Madrass immediately; but they next marched to Chinglapermacoil with a design as we imagined to make some Attempt on Chinglaputt,* *but we have since learnt that Mr. Lally having received advice that our Reinforcements were on the Malabar Coast, and consequently not likely to be at Madrass till February a Council was call'd, and a Resolution taken of attacking our Capital without attempting Chinglaputt.** Accordingly the Enemy moved to Vendalore, and Colonel Lawrence who had about 1,000 of our Troops at the Mount, knowing the Strength of his Situaton never cou'd impede the Enemys advance to Madrass, retired to Choultry plain, and from thence the 10th December at night to the late Dr. Munros (at present Mr. Turings) Gardens, and some adjacent topes; which Post had been chosen that Day for the strength of its Situation, and was intended to be fortifyed the next morning. The Avenues from St. Thomé were to have been barricaded, and two small Guns with an officers command were sent to Egmore Redout; so that it was thought by this Disposition the Enemy wou'd find it very difficult to approach Madrass. However by day light the 12th in the morning the greater part of their Force was seen near the ground our troops had quitted in the night, where we canonaded them an hour or more, and then observing that the Enemy were making a disposition to attack us, Colonel Lawrence with Reluctance, tho' in obedience to his Instructions founded on the expectations of our Succors, retreated in good order to the Island, as did the party at Egmore, and a body of Seapoys who were dislodged by the Enemys black Troops from St. Thomé. Our whole Force being thus united several partys were sent to possess the Avenues at the Entrance of the black Town, and the rest marched into the Fort.

12th. The Enemys main Body encamp'd on the Plain near Turings Gardens, but some picquets were lodged at the Companys Gardens, and Mr. Stevens's. Nothing else remarkable happened this day between the Enemy and us, they seem'd to be reconnoitring the South, and West Fronts, and we were busy in making general dispositions for our Defence.

Wednesday 13th. This day the Enemy seem'd to be reconnoitring the South and West Fronts, which gave us an opportunity of firing a few Shot at their Partys from some field Pieces in the Black Town,

° And most certainly the conquest of that Place was their intention from which nothing cou'd have diverted them but the important advice Mr. Lally then received of our Reinforcements having been on the Malabar Coast: In Consequence of such Information a Council was called of the principal officers and a Resolution taken that no Time was to be lost, but an immediate Attack to be made on Madrass without attempting Chinglaputt.°

but nothing very material past between us. The South Side where two new [a] Works were just begun being by far the most exposed to a Coup de Main which it was strongly presum'd the Enemy wou'd attempt, a Field officer with a Stout party was sent to lie all night in the South covered Way, and the strictest orders given to the officers on the other Post to beware of a surprize, which was the more to be apprehended from the Number of people, Cattle &c.[a] crowded on the Glacis, and under the Works round the place. Three posts which we held in the black Town were also reinforced, not with a design to make an obstinate Resistance, but if attacked to do the Enemy what Prejudice they cou'd, and retreat towards the Fort in such a Manner as to run no risque of being cut off. The Number of Troops on Duty yesterday, and to Day, was so great that I found it impossible to get any appointed for a working Party; and confusion prevailed so much among the blacks, that I cou'd only secure some of the Mistrys, and a few Common Carpenters, and Smiths. The Deserters who come in pretty thick, inform us that the Enemys force when united will be full 3000 Europeans of which 400 are horse that they have no heavy Cannon or Mortars but expect some daily, Their Black force may be about 2000 Horse and as many Seapoys.

Thursday 14th. The Enemy having marched from their encampment about the middle of the night, entered the black Town on the North, and West about three this morning; The opposition they met with from our Sepoys, and Europeans, posted at the several Passes was very trifling; but by good fortune our people got all safe to the Fort. By day light the Enemy were in full possession of the black Town, hoisted their Colors soon after at the Armenian Church, and fired some scattering Shott at our people on the Glacis from the Tombs at the burying ground. Lieut.-Colonel Draper making an offer about Eight O'Clock to attempt dislodging the Enemy while they were yet unsettled, and perhaps plundering, a body of 350 men or more and the two Granadier Companys were paraded for that purpose. With these and two field pieces he marched out at St. Georges (or the western) Gate and passing quickly over the bridge into the Pittah *Detached Majr. Brereton with 150 men along under the hospital hill as denoted by the black dotted Line to observe the Enemy on that side while he Col. Draper with the remainder and the Guns* marched thro' the Street as shown by the dotted Line, (1) till he came to (3) where he perceived some of the Enemy and received a scattering fire; to check them he left two Platoons and marched on with the rest to the position (6) where he had a fair View of the Lorraine Regiment and Indian Battalions on the flank

[a] Vide Plan.

at (4) for they expected him in another Street a little higher up (2) and had pointed 4 Guns in that Direction. Our Cannon at (6) began to play briskly with Grape and with the Musquetry made such havock among the Enemy that they soon fell into Confusion and ran across the Street under cover of some hutts. Col. Draper then advanced towards their Guns from which they had only fir'd three shot, and exchanged a Pistol with the officer, who offered to surrender them, but in spite of all his entreaties only four Granadiers wou'd follow him, the rest of our troops having like the Enemy thrown themselves in among some old Walls and under cover of houses kept a popping fire on each other. This gave the Enemy time to rally, and confusion became so visible among our people that Col. Draper thought it most prudent to retreat which he begun by Marching down the street as the dotted Line (8) Shows, but unfortunately above 80 of our Men not paying a due regard to the motions of the rest were shut up in the square (7) by the Enemy and taken Prisoners; this in some measure stopt the Enemys pursuit, and Col. Draper being joined at (b) by Major Brereton who had marched to support him with a party of 150 men he left his Guns, and continued his retreat with little loss to the Fort, notwithstanding the Regiment of Lally came from the Armenian church to the little bridge (10) and with 2 pieces fired Grape at our troops passing along (8) but they mostly fell short. Cou'd Regularity and obedience to the officers orders have been preserved among the Men in this Sally, it might in all probability have prevented the Siege of Madrass, and have ended in the total over throw of the Lorraine Regiment, and the two Battalions of India; As it was they had 30 officers or more killed and wounded, and near 300 men besides the Count D'Estaing, a Brigadier taken Prisoner in the beginning of the Action. Our Loss of men was 103 taken, of which 19 were wounded, about 50 left dead on the spot, and the same Number came in wounded; so that we suffered a Diminution of more than 200 men, and 9 officers. The Enemy during the Sally fired several Shot from some field pieces into the Fort but did no damage; they were quiet the remaining part of the Day, and we only fired a few Cannon on those places where we imagined they were at work. Count D'Estaing desiring leave to write a Letter to Mr. Lally it was granted, and a flag of truce sent with it. A Letter was wrote at the same Time from Colonel Lawrence recommending our wounded Men, and officers to Mr. Lally's humane treatment; which by his Answer he assur'd him they shou'd have, in the same manner as his most Christian Majesty's Troops.

No Europeans were to be had this Day for a working party, but I luckily collected a few Cooleys, Bricklayers, and other Artificers, and set them to make a Dam in the Gut at (c) to shut up the Communi-

cation between the Water in the River and Ditch, lest the Enemy shou'd cut the Dam (d) which kept up the Water two feet or more, and thereby drain so much off. This was a piece of work on which much depended, and which with difficulty I got finished before night. I also set up a Pallisadoe in an opening under the South Flank of the Royal Bastion, (e) and remov'd some Gabions, Fascines, and other Materials which were in the Way on the Ramparts.

15th. Several Deserters have come in from the Enemy this Day and Yesterday, who all agree in their reports that the Enemy lost many men and officers in Yesterdays Action. The Enemy fired not a Shot this Day from Cannon or small Arms, nor have they been perceived any where at Work, tho' we have many informations of their erecting Batterys, and fire now and then at the suspected Places. We cannot learn yet that they have any Mortars or heavy Cannon with, or near them; but tis said a Ship is coming up with all kinds of Store from Allemperva. By the Enemy's reconnoitring and Situation it seems as if they intended to attack the North Front by the N. East Angle. I therefore considered what was most necessary to be done to oppose them, and resolved to compleat the blind which I intended before the Old N. East Bastion, and to erect a Fascine Battery on the Glacis before the Shoulder of the East face of the North East Bastion; which Battery is to reach quite down to the Surf, and intended to sweep under the bank of the Glacis which had been cut down by the Sea, and afforded good cover for an Enemy. It was also Determined to set up a Pallisadoe before the Sea Gate, and to close up with stones the small Gate on each side the large one. A Captain, Two Subalterns, and 100 Men besides all the blacks I cou'd collect, were ordered on the above Services, with Messrs. Leigh, Eiser, and Stevenson Engineers.

16th. Yesterday evening I had orders to prepare people with proper Tools to cut away the floor of the Bridge leading from the West Front to the Hospital Hill, and to remove the old Draw Bridge which lays over the Canal on the Saliant Angle of the Royal Bastion. I accordingly ordered a party of Lascars and Cooleys under Mr. Leigh to perform the latter piece of Service; and some Carpenters under Mr. Stevenson, to be on the former, each of which was to be covered by a party of 12 Granadiers, and the Work to be performed between Eleven and Twelve; but the whole was countermanded, because it was apprehended we might suffer from it greater Inconveniencys than the Enemy. A Party of 40 Voluntiers, and 40 Sepoys were this Night order'd out about Eleven o'Clock to give the Enemy an alert, and if possible nail up some pieces of Cannon which it was said were in the black Town, but they had not proceeded much beyond the Glacis before the Enemys advanced Centinels gave their fire, and alarmed their whole force, so that our party on

hearing the Drum beat to Arms retired. A Party of 100 Soldiers, and 65 Sepoys were this morning paraded for working, and distributed chiefly to the Works mentioned yesterday, which were nearly finished by night; and the Pallisadoe round the Sea Gate Virando entirely compleated. Fascines were also laid round to form a Parapet on that part of the Sea Gate Battery which had none; and some sand Bags laid for the same purpose in part of the Barbet Battery towards the Sea. Earth was also laid on the Arch over the Magazine under the old West Curtain and over part of the hospital adjoining.

17th. Last night about Eight o'Clock the Enemy gave an Alarm by a few Men coming near the Glacis, and giving their fire. Nothing remarkable happened afterwards. This Day 100 Men, 2 Serjeants, and 1 Corporal were on a working Party but the Weather being very rainy, little was done. They, and about 200 Blacks were chiefly employed on the two batterys mentioned the 15th to the N. East, in thickening the Parapets of the old N. East Bastion; compleating the Barbet Battery with sand Bags; laying Earth on the hospital Arches, fixing a Pallisadoe to close the Communication from the Covered Way on each Side to the North Ravelin, and repairing some Checks of the Embrasures on the Demi Bastion; besides other trifling repairs. The Enemy was not for certain perceived to be any where at work; tho' single Guns (by Way of security in the night I suppose) were perceived in some of the Streets. Very few Shot were fired by us and less Shells during this Day. Several Deserters came in last night and this Evening, from whom we learnt the Enemy had some Mortars arrived at St. Thomé. The Governour this Day gave it out publickly that he wou'd distribute 5000£ among the Garrison five days after the Siege was rais'd or the french beat off.

18th. This Morning it was perceived that the Enemy had thrown up a breast work (Vide Plan A) from the houses on the beach near the old Town to the Sea Side, but whether intended for a Battery, or to prevent any attempt of ours on their flank cannot be said, tho' I believe the latter because the trench from whence the Sand has been taken is on the side of the Enemy contrary to the Method of making Batterys; something of the same kind was perceived in the Streets next the Sea, but no Guns or Mortars have yet been fired, or appear'd ready for that purpose. On our Side a very few Shot or Shells were thrown. The Gentlemen of the Squadron, and Marines, who had been on board a Dutch Snow the 12th with an Intent to go and take the French Ship which is coming up with their Stores, were this morning landed being very unwilling to undertake the expedition, and having been detained by bad weather so long in the road, that it was supposed they were discovered. Captain Jasper who was

to have commanded them appeared much chagrin'd at his Disappointment, and indeed with reason, for had he succeeded, and I think he had great reason to expect success, nothing cou'd have done us more service, or the Enemy greater Prejudice. A great many people were perceived to Day moving from the Mount towards the black Town, which we apprehend are bringing up the Enemys Stores. It is very remarkable that 33 deserters have come in from the Enemy since their arrival, and not one man has deserted from the Garrison or been seen in Liquor.

A Peon came in and informed us, that Captain Preston had sent out a Party under Lieut. Airey from Chinglaputt, which had intercepted a Convoy of the Enemys stores consisting of a Large Mortar which he spiked up, and burnt the bed, 2 Guns which he also spiked, and burnt the Carriages; and some Ammunition which he carried off with all the bullocks. No Deserters last night, which is owing I suppose to some extraordinary Care or orders of Mr. Lallys. The Working Party was this Day about 100 Men without officers. They, and the black Artificers were chiefly employed in fixing a Pallisadoe before the new Battery by the Sea Side, opening another embrasure in that Battery, cutting down the high bank which the Surf had made by washing away the Glacis; thickening the parapets of the old North East Bastion; repairing the embrasures with Palmeiras which had been blown away by our own Guns; laying Earth on the hospital; fixing a Pallisadoe in the Gorge of the North Ravelin; and repairing a Dam (c) which had been made in the Gut to the North West to keep the Water in the Ditch, but the Water had rose so high by the last four Days rain, that half the Dam was destroy'd, and the Water considerably sunk. Several other Jobbs of a trifling nature were also executed.

19th. This Morning we perceived that the Enemy had thrown up another breast work about 50 feet in Length and 100 Yards or more advanced before that thrown up the preceeding night. Both these Retrenchments terminate on the Surf the latter at the distance of about 500 Yards from the N. East Saliant Angle of the covered way, and seem rather intended to cover a Guard posted there to prevent a surprize or desertion, than for any annoyance to the Fort. However from the proceeding of the Enemy it appears as if they intended to advance along the beach, and attack the Demi, and North East Bastions; it is therefore resolved that Platforms shoud be raised in the covered Way sufficiently high for field Pieces on covered Way Carriages to fire over the Parapet. It is further resolved to raise the Parapet of the Demi Bastion near the saliant Angle two or three feet higher than the rest, and to erect a Traverse on the East wing to prevent an enfilade. To raise the blind before the N. East Bastion so high as will just admit the Guns to fire over

it at the Enemys Works. That the passage between the upper, and lower flank of the Demi Bastion shou'd be closed in the securest manner, and that the North Ravelin shoud be put in the best condition of Defence we might have Time or Workmen to do. The Working Party of about 100 Men with such Cooleys, Pallankeen Boys, and others as I cou'd collect, were set about the several Articles before mentioned. The firing on our side was very little to Day except from Wall pieces, and not even a musquet Shot came from the Enemy. Five Chalingas were seen this morning going out of St. Thome Bar, and saild to the Southward, as we apprehend for Stores.

20th. Last night the Subaltern on Duty in the N. East Angle of the covered way with 21 Men, and some Sepoys, was ordered to Sally on the Retrenchment and works which we supposed the Enemy was carrying on, but it being rather too light, they were discovered and the Sepoys taking a Pannick at a party of 6 horse which appeared, ran away, which intimidated the Europeans, and they, after giving their fire retreated also without doing the Enemy any other Damage I believe, than giving an alarm. We were not so fortunate, for one European was killed, and two dangerously, if not mortally wounded: The Sepoys suffered in the same manner. The Commandant of Sepoys Pemaul Saib being desirous of attacking St. Thomà last night was sent out with 10 Companys of Sepoys, but taking the direct road over the long Bridge he was discovered by a few French Sepoys at Mr. Powneys house who gave him a few Shot and his people many of them threw down their Arms which induced him to return without performing the least piece of Service. The Enemy we cou'd perceive this morning had been at work last night and to appearance drawn about 50 Yards of a Parrallel westward from their most advanced Breast work. They also had got a Gun behind their first breast work, and from thence fired several Shot at the Snow which lay in the Road under Dutch Colors. The Shot mostly fell Short, one or two entered, and killed a Lascar; the Vessell therefore weighed and stood a little farther off, as well to avoid any annoyance from thence as to prevent a Surprize. A Mossala appearing off St. Thome, a Party of Marines were sent in three Mossulas to fetch her in, which they effected, and found her to be a boat going from Sadrass to Pulliacat. The Working Party was this Day 100 Men, and employed as Yesterday except on the old N. East bastion the Parapets of which were finished. This afternoon the Artillery Serjeant on the N. East Bastion intending to fire a discharge of Grape at some of the Enemy which appeared at their Breast works, unfortunately some scattering Shot fell* into the

* Grape Shot in Spite of the greatest of Care spread and drop so much that tis not safe to fire from any work while any of your own Troops are posted in the covered way or near it.

covered Way, and miserably wounded three Cooleys, who were rolling a Gabion upon the Work there carrying on.

21st. Last night we fired Shot or Shells every 8 or 10 minutes on the place where we suspected the Enemy wou'd work, and by that means prevented them from doing any thing more than throwing up an imperfect Communication from the first to the second breast work. Advice being brought in last night that the Enemy had 2 Guns at Trivelcane and very few Troops at St. Thomá about 10 o'Clock in the morng. near 1000 Sepoys with 20 Europeans Commanded by Town Major Bannatyne and Ensign Crawley went along the Beach to the Southward, cross'd the Bar, and march'd thro' the Village beyond the Governors Gardens, where they surprized two or three Small Sepoy Guards, intercepted some Letters, took a troopers horse and Arms, and one Soldier Prisoner, but on advancing down the road towards Mr. Turings house, they perceived a body of Europeans and blacks, which they were not a match for, and therefore returned by the Way they went. From the Fort house we perceived in the mean Time 2 Guns perhaps 18 or 24 Prs. the one drawn by Bullocks 15 or 18 Yoke, and the other by Bullocks and Cooleys passing from Chind-adree Pagoda across the Plain towards the Potters Village, but being near enough for our great Guns to reach them, some shot were immediately fired from the Nabobs Bastion and Lawrences, which soon made the Cooleys and Bullocks halt, and one of the Guns sinking almost to the Axle Tree at the same time, it was proposed to send a party of 300 Sepoys with a promise of a great reward to nail up the Cannon. They were accordingly sent out at the western Gate on the sight of which and our firing, the bullocks were cast off from the Guns, and the Cooleys ran away, leaving the Guns alone. Our firing and the Motions of the Sepoys alarm'd the Enemy in the black Town, so that about 200 European horse were sent in all hast towards the Guns, and their foot marched to the west side of the black Town to support them ; This we perceived and fearing the Sepoys might be cut to pieces sent orders for them not to advance beyond the little bridge leading from the Island to Egmore. The Enemy by these motions were entirely Alarmed, and we had an opportunity of firing many shot at their horse and foot but the Execution was uncertain. About 4 or 5 in the Evening more Cooleys and Bullocks were sent to fetch their Guns, and in spite of our fire carryed them off towards Mr. Turners Garden house where I believe they were left for that night. The Working Party the same Number, and employed, as Yesterday.

The Nabob and his family were last night sent on board the Snow in the Road with Mr. Norris a Councellor, and sail'd this morning for Nagapatam where it is proposed the Nabob shall land, and proceed to Trichinopoly, that he may still have a greater Chance of recovering his Nabobship, and disturbing our Enemy. Mr.

Lally by a Letter to Count D'Estaing yesterday, complain'd that *Usoff Cawn was committing great devastations to the Southward near Pondichery, and that he shou'd in Consequence be obliged to make reprizals round Madrass. As to that, he cannot well depopulate the Country more than he has, for tho' he may be obliged to retreat it will be long e'er Madrass recovers its Inhabitants, and becomes a place of trade. This Evening two or three boats were seen coming from the Northward, and Landed on the beach of the black Town so that we conclude the Enemy had sent for them to attack the Snow which sail'd in the night.

22nd. Last night the fire of Shot and Shells on the Enemy was as in the preceeding nights. In the Morning, we discovered that they had thrown up some Earth towards forming an Epaulment for the Security of Communication from Pedda Naigues Petta to the Portuguese Church across the Low Ground near the new house begun by Hendrick Smith; that they had barricadoed the Street, North, and West of the old Hospital, and plac'd Guns there; and that they had worked a little at their communication between the breast works. By a Dutch Tappy Peon who had been Siezed and made to work five or six Days with the French, we were informed of their having made several Batterys behind the houses to the North, and West, in so circumstantial a Manner that it appeared very probable; however on considering their situation I am apt to think they are chiefly for their own Security. This Evening about 4 o'Clock a large Vessell was seen to the Northward which at sun Sett being then about 4 Leagues off furl'd all her Sails but the Fore and Mizen topsails and stood with her head towards the Land; No Colors being discovered leaves us uncertain whether it be a Ship of ours, or a Ship the French say they expect from Mazulipatam with Stores. The Working Party was 100 Men, and employed in General as before, except those on the Demi Bastion where the Traverse being finished, they were set to repair some part of the face, and front, of two Merlons which had fallen down in the late rains.

23rd. The Cannon or Mortars fired last night every ten Minutes on the Enemy in order to disturb their Workmen, who by morning had depened and Lengthen'd their Parallel a few feet. They had also been at Work on their Line of Communication between Mutall Pettah, and Pedda Naigues, but had not finished either that, or the Work they had been on elsewhere. About 8 or 9 in the Morning a Sail appeared to the Northward, and anchored about 11 o'Clock. She Saluted with 9 Guns which we answered with 9 Shot into the black Town. This Ship was the Thames from Vizagapatam in four

* Commander of our black forces to the Southwd. who was ordered to march this Way with 2000 Sipoys and as many horse.

Days, and brings us advice of Colonel Forde having given the Marquis de Conflans and the French Forces under him an entire defeat; the further particulars of which must be deferr'd till the Letters are landed, the wind blew so fresh, and the surf ran so high, that no boat cou'd get off. However that the Enemy might not wait so long, we had all the troops in the covered Way, and gave them a *feu de Joy* from our Musquetry and three times 7 Twenty four Pounders with Shot into the black Town. The Vessell which appeared last night is still at an anchor 10 or 12 Miles to the Northward, and is concluded to be a Vessell of the Enemys from Mazulipatam with advice probably of their defeat, and perhaps with Stores.

24th. The Wind blowing very hard last night it was apprehended the Thames which had only one Anchor and Cable and drove, wou'd have been obliged to quit the road, however she rode it out, but on seeing the Vessell to the Northward weigh and Stand towards the Road, she weigh'd also, and strucked off to Sea; In the afternoon she attempted to fetch in again, but by the Evening was out of Sight to the Southward. The French Vessell came opposite the North End of the black Town, and anchor'd. The fire of Shott and Shells last night on such Places as the Enemy was suspected to be working at, was some what more frequent than the preceeding Evening. And by what we coud discover they had only enlarged their Parellel a little, and placed a few Timbers within to keep up the Earth. The Working Party was about 100 Men and was employed on the blind before the old N. East Bastion, and in raising the Parapets of the Royal Bastion. The Blacks in facing the Embrasures of the Northern works, and finishing the Traverses of the North Ravelin. This Evening a Soldier was executed for attempting or threatening to Shoot his Serjeant. Finding that the Soldiers on the Working Partys were some what unruly, orders were given out at my request, that all people so employed shou'd strictly obey my own, or Assistants orders, and in case of neglect be severely punished. Mr. Cotsford a Companys Servant was appointed Practitioner, and to rank as Ensign.

25th. The fire from our Cannon and Mortars was kept up last night as in the preceeding. The Enemy as far as we cou'd perceive had done very little work, and that only in deepening and thickening their Parellel. Our Working Party was 100 Men besides some few Lascars, about 30 Cooleys, and 50 or 60 Sepoys. They were in General employed as yesterday except in removing the Fascine Parapet on the Sea Gate Redout, and making another of Gabions. The Traverses of the North Lunette were this Day finished, and the Platforms of the Demi-Bastion were lengthened 8 feet with sleepers and Plank. The Govr. and principal officers having assembled this Evening, and considered some Intelligence they had received of the

Enemys erecting Batterys, agreed that the most necessary work at present was finishing the Traverses on the Royal Bastion, and then closing the opening between the Northwest Curtain* and the blind before the Mint Sally port. Also erecting a Traverse in the covered Way before the North face of the Royal Bastion. Last night as a Corporal was patroling on the Glacis to the Northward a Sepoy fired at him and shot him dead.† In the forenoon a Sloop appeared to the Northward standing this Way, but the french Ship hoisting her Colors when the Sloop came abreast, and firing two Guns, the Sloop anchor'd, and soon after stood in under the Ships stern. She had white Colors but appeared to be a Moors Sloop.

26th. The fire of our Artillery and Mortars was last Night pretty smart, and we cou'd not perceive that the Enemy had done any thing on the N. East. On the West in the Street going into Pedda Naigues Pettah near the old Hospital we perceived they had placed some green Gabions and made a work, but it appeared to be rather a retrenchment across the Street than a Battery. There was also something very like or actually a piece of heavy Cannon in the Street, at which and an old Wall some Shot were fired to Day, but their effect was not very great. A Small sloop passed by in the offing. The Serjeant who for a long Time had had the Care of the Keys of the Garrison, being sent in the Night to let out a couple of Hircars, took that opportunity to desert, and carryed off the Keys of two Barriers at St. Georges Bridge. He also carryed off 800 Pagodas belonging to a Comrade who had Lodged it in his hands. The Man was generally esteem'd a quiet careful Person, but being nearly detached detected in a concern of Arrack selling, and apprehending Punishment it is imagined was the Cause of his Desertion.

27th. Last night a pretty brisk fire was made from the Cannon and Mortars on the North front, on such Places as it was imagined the Enemy were at work. An Hircar came in from Chinglaput in the night, and brought Letters from Usoff Cawn of the 23rd when he was a Days march from thence with a considerable black force, and expecting to be joined by Major Caillaud every Day. The Enemys Black force it is said are gone to meet him. A Cattamaran also arrived from Pulliacat and brought Letters from the Resident there, advising that he had a Patmar from Bombay. The Working Party was 100 Europeans and 250 Sepoys employed as yesterday.

28th. The fire from our Cannon and Mortars was pretty smart in the night on such places as we imagined the Enemys were at work. In the Morning we discovered that they had thrown up some Earth among the Ruins of the houses a little to the North of

* Vide Plan (f).

† This Accident and some others of the like Nature by means of the Sepoys irregularity prevented a good deal the frequency of Patroles.

the old hospital, and that they had thickened and heightened their work to the North so much that it had more the appearance of a Battery than Parellel. By some Motions which we observed of the Enemys black Horse from Egmore towards St. Thomá, we concluded the Enemy had advice of Usoff Cawns near approach. A Paddy Boat or Sloop came in from the Northward, and was stopped by the French Ship. The Working Party of 100 Europeans and 300 Sepoys was employed on the Works already mentioned.

29th. The fire of Shot and Shells to the North and West was pretty brisk in the night, however the Enemy had been hard at work, for in the morning we perceived they had form'd a stout Parapet to the Westward, and to appearance had three Embrasures in it tho' they were not opened the Intent seems to be to fire on St. Georges Lunette the Bridge of Communication to it, and the Communication to the Bridge leading to the Island. Their Work to the Northward appeared now very plain to be intended for a Battery in which I observed five rows of Pickets placed at equal Distances as Centers of Embrasures, and by the length of the work there might be room for four more. The Direction seems to be against the North face of the old North East Bastion, and the North face of the Demi Bastion. In the Night Hircars came in from Usoff Cawn acquainting us that he was at Vendalore, and about 10 in the Morning we perceived a Red flag on the Mount instead of the white there before; so that we concluded Usoff Cawn had Possession of that Post. The Enemy this afternoon appeared to be working on their Battery to the Northward, and several pieces of Timber and Plank were seen carrying thither for Platforms. Towards the Evening I also discovered a large Mortar placed on the Communication between the two Breast work first begun by the Enemy near the Sea Side, from which is to be suppos'd they will soon salute us. About Sun Sett a Deserter came in from the Enemys Works to the Northward. The Working Party of Europeans was 100 men and about 300 Sepoys employed as yesterday.

30th. The fire of our Artillery and Mortars was last night pretty brisk, and I believe prevented the Enemy from working much, for I cou'd not perceive any great addition to the Northern Battery. To the Westward I observed they had thrown up a good deal of Earth behind some old Walls which seems to be intended as a Battery to enfilade the North Face of the Royal Bastion, and the covered Way before it, but the form is as yet very incompleat. In the night a boat came from Sadrass and brought some Letters of the 18th from the French Army to Pondichery, which Captain Preston had intercepted. From these we learn that the Enemy lost by our Sally on the 14th about 220 men and 30 officers killed or wounded. In Short they acknowledge themselves to have been thrown into the greatest

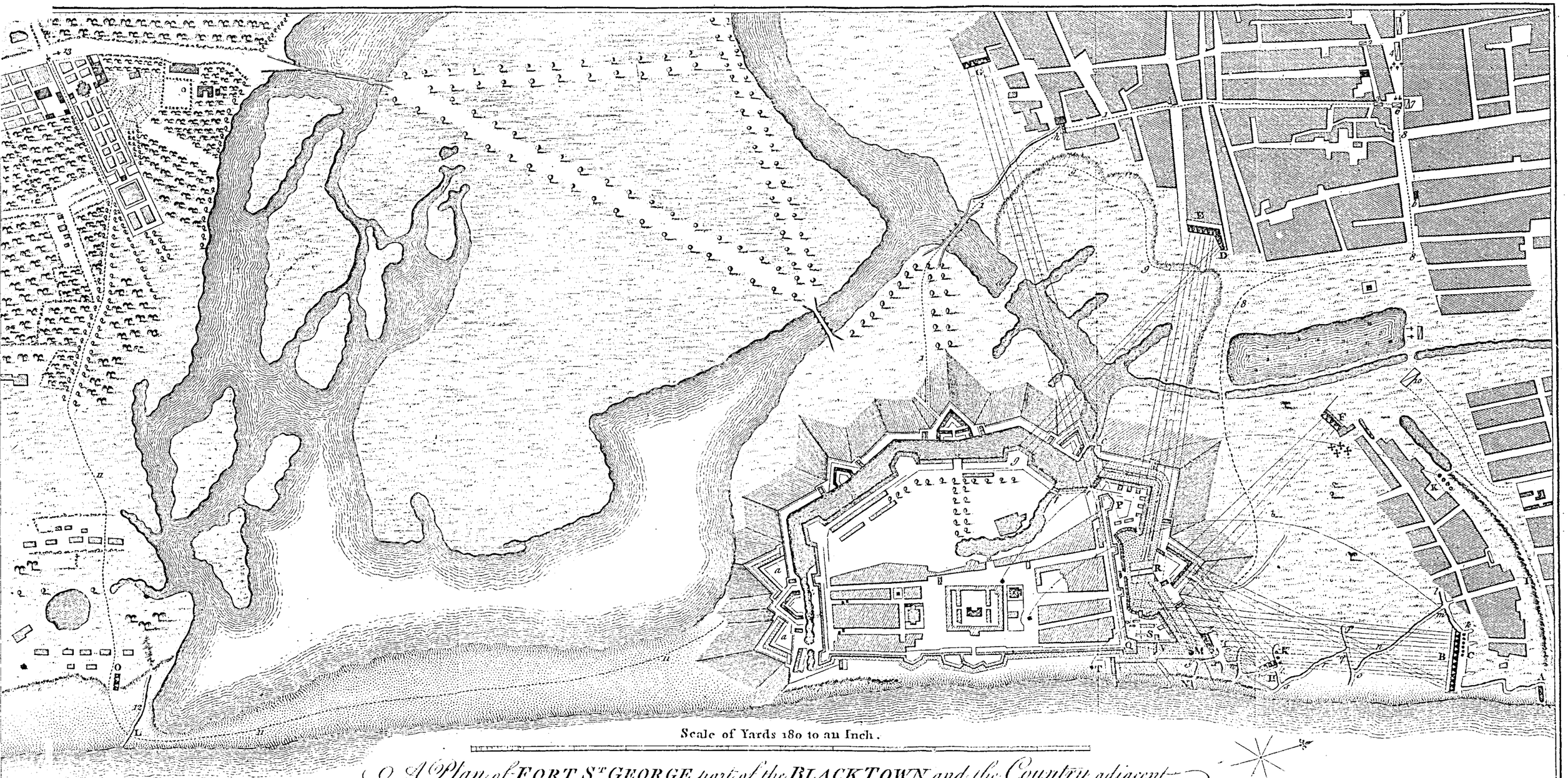
confusion, and that they must have been entirely ruined had our party advanced more regularly on them, and been supported by another body to the Northward. A Letter from one of Mr. Lallys Aid de Camps to the Council at Pondichery complains much for want of money, and desires they wou'd supply him with some, if it be but 100 Rupees and that too chearfully; for their affairs were in a fair Way, and the conquest of Madrass certain. In the Morning we perceived a great smoke at the Mount, from whence we concluded the Nellore with his whole force was there. This was confirm'd by an Hircar coming in at noon with advice that there had been a skirmish and some French Troopers taken. A great Number of black troops horse and foot with large herds of Cattle were observed to come from the Mount and St. Thomé to Egmore; and two Guns were sent from the Black Town thither. Another Deserter came in this afternoon, and in the Evening a flag of Truce with a Letter from Mr. Lally complaining of our firing at his head Quarters and threatening to burn the black Town in return but of this he had no right to complain, because he is the first General perhaps that fixed his head Quarters within point blank Shot of the fort, and Lodged a Regiment, and his Ammunition at the same Place. The Working Party 100 Men and 300 Sepoys, employed as before except on the blind before the old N. East Bastion which was finished yesterday.

31st. Last night and towards the morning particularly the fire from the Cannon and Mortars was rather smarter than before. At Day break a large body of Sepoys, the 1st Company of Grenadiers, and the Troop of Horse went over the barr to the Southward, and into Trivelcane Village where they surprized a small Guard or two of Sipoys, and intercepted several Letters from which we learn that a Frigate was arrived from the Islands to Pondichery, and had brought about 200000 Dollars, but no mention was made of any Force. The going out of our Sepoys gave Mr. Lally the Alarm, so that three or four Picquets of Europeans, and some white horse with Guns were seen marching from the black Town to Egmore. A Party of 40 Europeans and as many Sepoys in 8 Boats were sent off in the night to stretch a Chain out to the Eastward, Lest the Boats to the Southward which had brought the Enemy Ammunition shou'd slip by, and land it to the Northward. Letters came in about 10 in the Evening from Capt. Preston and Usoff Cawn acquainting us that in the morning the Enemy in Number about 1000 black and white under Colonel Kenelly, had about day break advanced four Guns near the Mount, and Cannonaded him, which our people answered so briskly that the French retreated, afterwards they came on with two Guns which our people made a push at and took, killing 15 of the French on the spot and wounding Colonel Kennely, 1 Captain and 25 Men. An Artillery Man and Hussar came in last night or

this morning. In the Afternoon a large Ship appeared to the North East and by Sun Sett was near East of the Fort, with the Hull just appearing. The French Ship hoisted first English Colors, then french, and fired two Guns; but the other Ship stood on to the Southward, and show'd some Colors which had a white field, perhaps Portuguese. The Enemys work to the Northwd. appear'd to have received no addition this morning, but that to the *Westward plainly appeared to be design'd for two batterys; one in which three or four Embrasures were form'd apparently to fire in the Northwest Lunette, and the other of 5 or 6 Embrasures not yet traced to infilade the face of the Royal Bastion, and cover'd Way before it. The Working Party consisted of 100 Europeans, about 40 Cooleys, 30 Lascars, 10 Pions, the Mestry Bricklayers, and about 60 Sepoys who were all employed on the several Works before mentioned.

* Vide Plan D.E.

(To be continued).



Scale of Yards 180 to an Inch.

A Plan of FORT St. GEORGE, part of the BLACK TOWN and the Country adjacent as it was when besieged by the French, 12 December 1758.

T. Jeffrys Sculp.

MEMOIR.

MAJOR-GENERAL ROBERT DUFF.

ON 2nd December last, after a short illness, Major-General Robert Duff, R.E., passed away in his 83rd year, at his home in Berkshire. He entered the Corps in 1850, and in 1853 was ordered to the Cape where he served until 1858; and he thus missed the Crimean Campaign and the active service of the Indian Mutiny. The later years of his service, about 25, were passed at home stations.

The name of Capt. Duff will always be remembered by his excellent work in the organization and equipment of the mounted branches of the Corps. Under the late Sir F. Chapman, K.C.B., and Sir Lintorn Simmons, K.C.B., as C.R.E.'s at Aldershot, Duff carried out all the early stages of mounting, equipment, and training of the Pontoon and Telegraph Trains, and worked untiringly for 11 years at Aldershot. The years after the Mutiny were full of Army reorganization, and during his constant attendance at the War Office on Corps business, Capt. Duff became personally acquainted with Lord Hartington, the Under-Secretary of State for War, and gained his confidence to such an extent that he consulted him as to reforms and rearrangement of stores, etc., at Woolwich, and largely adopted his views. Officers of the Corps who served with him at Aldershot in the Train speak in high terms of his exertions both in command and grasp of duty, but they also tell of serious overwork and consequent loss of health.

The reaction that always takes place after war at one time threatened to take the form of reducing the establishment of the R.E. Mounted Branch, and it was only averted by the personal influence of Duff with the Under-Secretary of State for War, always supported by our own officers.

In 1865 Sir L. Simmons as C.R.E. brought forward the "important and meritorious services rendered by Capt. Duff in the formation of the Royal Engineer Train, and the organization of its equipment" for the special notice of H.R.H. the Commander-in-Chief. Reference was also made "to the valuable assistance Capt. Duff has rendered in connection with the Store Department at Woolwich," and the Commander-in-Chief expressed his approbation of his "valuable services." In 1879, as Lieut.-Colonel at Shorncliffe, the

D.A.G. offered to submit his name for the appointment of Assistant Commandant at Chatham. He had previously declined to work at the War Office as Assistant Director of Works for Barracks. He held the post at Chatham for $2\frac{1}{2}$ years and then retired in 1881 with the rank of Hon. Major-General.

Any appreciation of our brother officer would be inadequate which did not relate his remarkable work in creating the Golf Club at Homburg in the years 1896–99. The task was difficult : the health-seeking visitors could not go far afield for amusement, and Duff, having, with greatest patience and tact, overcome the objections of the local authority and the sensitiveness of the visitors, started with a few putting greens in the park, actually amongst the patients, in 1896–7 : he then devised a miniature links with holes up to 100 yards apart, for iron play only, in the open spaces of the park, and, in 1899, the Club was established with H.R.H. the late Duke of Cambridge as its first president. In 1904 the links were extended from 9 to 18 holes, the fairway being devised, with consummate skill, through gardens and plantations bordering the mineral springs, eventually winning the conviction of all that the only course had been adopted whereby the game could be pursued by those undergoing the Homburg cure which rendered would-be players unfit for the strenuous efforts of the ordinary game, and, at the same time, secured the suffrages of old golfers, so that the Club House became prominently the afternoon tea resort of the English visitors admitted to the Club.

" The Club House (designed and built by Duff as Hon. Secretary) had become recognized as the place at which all who had claims to distinction should meet at least once daily. Royal personages, cabinet ministers, ambassadors, peers, judges, distinguished officers and other lesser lights were constantly to be seen engrossed in play. Eighteen members of ruling Houses accepted membership, among others the Crown Prince of Germany and Prince Henry (the Emperor's brother) who has repeatedly played on the course."—(Memo. by British Consul Frankfort).

The Club prospered from the start and rapidly increased its membership to 2,400, and the Hon. Secretary had the privilege of assisting King Edward VII., the Kaiser, and many other notable visitors in the Royal and ancient game. General Duff resigned the post of Hon. Secretary in 1912 with valuable souvenirs of his tenure of office.

General Duff married in 1866, Beatrice, daughter of the late James Maxse, and granddaughter of the fifth Earl of Berkeley. She survives him. Their only child married F. Sharp, Esq., of Ascot Lodge, only surviving son of John Sharp, of The Wilderness, Lancashire.

W.D.M.

TRANSCRIPT.

ON AN INDIAN CANAL.

By MAJOR-GENERAL G. K. SCOTT-MONCRIEFF, C.B., C.I.E.

(*Reproduced from Nos.* MCXII., MCXIII. *and* MCXIV., BLACKWOOD'S MAGAZINE, *with the permission of the Proprietors,* MESSRS. WM. BLACKWOOD & SONS).

(*Concluded*).

III.

FROM what has already been said on the subject, I hope it is sufficiently proved that an Indian canal is constructed rather for the benefit of the people than as a commercial concern intended as a source of profit to the State. As, however, there is a class of would-be philanthropists who imagine that all their countrymen in foreign lands are actuated simply by selfish motives and a desire to enrich and aggrandize their own country and their own class at the expense of the natives, it is perhaps desirable to emphasize this matter.

A friend of mine, a skilful and clever irrigation engineer, was dining with one of the pseudo-philanthropists above mentioned, and the conversation turned on the Punjab canal system. My friend mentioned with some satisfaction that the average profit, after all expenses were paid, was generally over 10 per cent. "And does all that money come out of the pockets of the people?" asked his host. "Yes." "Then I wonder you are not ashamed to mention it," was the reply, to the engineer's astonishment. "The idea of extorting such enormous profits out of a half-starved peasantry is absolutely monstrous. The State ought to be quite content with 4 or 5 per cent.," etc., etc. In vain my friend tried to explain that the basis of the whole system was the land revenue, that the State was regarded as the owner of the land (which, by the way, is the Socialist idea), that the tiller of the soil paid to the State the equivalent of a percentage—about one-tenth—of the produce, and that if the State supplied water which increased that yield of produce a hundredfold, the revenue would increase in like proportion. If by economy of design and management, or by the configuration of the ground or any other favourable cause, the cost of providing that water was small, the corresponding gain to the State was large, and *vice versâ*. But it was all in vain. The philanthropist could only grasp the idea—10 per cent. profit out of the pockets of the people; and in his eyes, blinded with prejudice and ignorance, it was iniquitous.

That such was not the opinion of the impoverished people of the country was brought home to me very forcibly one hot weather about the beginning of June, when I was carrying out some works on the left

or eastern side of the Jhelum, opposite to a little town called Jalalpur, where the Salt Range—a barren range of low hills—comes close to the river. A classic spot this: for here Alexander the Great crossed the river—the ancient Hydaspes—and fought a successful battle against superior numbers. Not far from this place also is the modern battlefield of Chillianwallah. The Salt Range recedes from the river below Jalalpur, leaving a wide and fairly flat space of ground for many miles—a region dotted over with villages and extensively cultivated. The natives of this region had asked for a canal, and I was ordered to examine the country and report whether the matter should be taken up seriously.

I sent my servants and baggage across by a ferry to a little rest-house at Jalalpur, intending to cross myself in the cool of the evening. At sunset I rode to the ferry accordingly, and without any difficulty crossed the first arm of the river, in a clumsy flat-bottomed barge, probably of a pattern that is unchanged since Alexander's day. But the main stream, about half a mile wide, had still to be crossed, and as the boatmen were towing the barge up the margin of a flat island in midstream, a tremendous duststorm came on, and we had to cower in the best way we could while the fury of the storm passed over us, obliterating every object from view, and rendering further crossing impossible while it lasted. As one waited there in miserable and involuntary patience, it was with sad regret that the remembrance of the charms of England in the lovely foliage of early June came to the memory. It was two hours or more before the storm had sufficiently abated for us to attempt to go farther, and by that time night had fallen. With some difficulty the boatmen were persuaded to proceed. Then followed a most exciting voyage over the brown foaming waves, rushing downwards in full flood, for the heat had brought down quantities of melted snow from Kashmir. It was a weird sight to see the almost naked figures of the boatmen silhouetted against the lurid night sky, as they rushed along the gunwales of the clumsy barge, making frantic efforts to push the craft across, the current meanwhile taking us down stream at a racing pace. We got across about ten o'clock, and I found my way to the rest-house, whence after a meal and a few hours' sleep I started, long before daybreak, on horseback to ride over the country on which I had to report. There appeared to be no impossibility in making a canal, and it certainly seemed as if the labour of tilling the soil was largely increased by the saline crust which had been washed off the hills by each rainy season, and which the farmers had been obliged, with infinite labour, to remove. I halted at a village to have a talk with the people, hailing a respectable man who was working there. When I told him my errand he gazed at me for a moment incredulously, then rushed off to gather some of his companions. Then ensued a most extraordinary scene. A crowd of men gathered round me, kissed my feet, grovelled in the dust.

"We have had nine bad harvests in succession," said one, "and if the Sirkar (Government) cannot give us water we must leave the place. It is our land, and our fathers have lived here for generations, but what can we do?"

"But," I said, "you will have to pay a higher land revenue, double what you pay now."

"We would gladly pay that, and far more."

It was with difficulty I was able to get away from them, and riding back to the little rest-house spent the long hot hours of the day writing a report recommending the carrying out of detailed surveys and investigation of a regular scheme.

Nine successive bad harvests! It was a most pathetic appeal from men who were evidently in sore straits. Yet these men were not absolutely famine-stricken, and it is to these especially that the Indian Irrigation Branch has brought relief. It must be, of course, recognized that there are many places in India where irrigation is, owing to the nature of the ground, impossible. Hence it is sheer nonsense to say, as some ignorant newspapers at home say, that a greater extension of canals would *prevent* famine.

But the more canals there are the more crops are grown, even in times when the rains fail, and the more food is produced in the country generally. Railways can transport that food to the places where it is most needed. Hence canals help to reduce the suffering caused by failure of the rains. Railways can also transport the poor famine-stricken people from a district where they are starving to places where canals are being made, and therefore where work can be found for the necessitous. Such an experiment was tried on a large scale on the Jhelum Canal in one of the recent famines. It ought, perhaps, to be mentioned that in every district there are certain schemes kept ready for the employment of people in case of famine. If possible, these schemes are designed to be of a profitable nature—not merely digging for the sake of doing so, but work which is necessary and useful. It is, however, not always possible to find work for the unemployed and feeble (a difficulty which occurs in other places as well as India); and when, in the case of the Jhelum Canal, it transpired that there was profitable work for thousands of people in a practically uninhabited land, it was evidently a wise course of action to send the people to the place where work on a large scale was in need of unskilled labour. So it happened that one day the executive engineer of the works got a telegram ordering him to expect 30,000 people in a month's time, bidding him report fully how he intended to employ them, ordering him to prepare huts for their accommodation, water for them to drink, tools for them to use, and to arrange with the Deputy Commissioner of the district for depôts of food at suitable positions. All this was done within the specified time, every detail being first fully worked out, estimated, and sanctioned by the local government; then contracts were got out, some 30 or 40 hutted camps built, wells sunk and fitted with the simple apparatus familiar to the people for raising water, depôts of tools and food prepared, and overseers detailed to show the people their tasks. A heavy addition all this to the work of men already fully occupied from dawn to dark, but the Indian official has to learn to work his mental and physical machinery with more than its normal loads, and an extra demand has to be taken as part of the day's work.

In due course the first 10,000 of the army of famine workers arrived in various special trains, were deposited at a little railway station about 15 miles from the scene of their labours, and there rested in a special camp prepared for them close to this station. A poor, disheartened, emaciated mass of humanity, of all ages and sexes, old bent men, withered

crones, and many little children. It was impossible to separate families, and so all sorts and conditions of men and women had come, with bundles containing their few possessions; a few cooking-pots and rugs, with possibly a beloved water-pipe, constituting, as a rule, the entire family outfit. The leader of this host was a young civil officer, well known a short time before at Harrow and Oxford as a good cricketer. The Deputy Commissioner of the district who received them was, curiously enough, an Eton and Cambridge man. It was on these two young Englishmen that the chief duty of looking after the people devolved.

The newly arrived gangs were drafted off into various working camps, and work was duly commenced, when a dire calamity happened. Cholera broke out. It was clear that they must have brought it somehow with them, for they moved into an uninhabited country; and although the water in the newly made wells tasted somewhat bitter, owing to the malodorous *pilu* wood used in the wells (there being no other wood obtainable), the medical authorities were unanimous in concluding that, whatever the engineers could do, they certainly could not manufacture the cholera bacillus.

Time would fail me to tell how heroically the European officers exerted themselves to allay panic, to segregate and to comfort the sick, and cheer the healthy. The disease was quickly stamped out, but it unfortunately prevented the remaining 20,000, for whom all arrangements had been made, from coming.

But those who had come soon began to flourish. There were, of course, some feeble old people and others too young to work; but for the most part everybody could do something, and there were tasks which could be given even to little children. It involved patience, kind treatment, very hard work, and unremitting attention; but these were not wanting. In addition to the European officers, some native gentlemen of good position volunteered their services, which were gratefully accepted. One of these, for instance, took as his special charge the camp set apart for orphan children, and it was pathetic to see how quickly he gained the affection of these waifs and strays.

When the work was well established it was visited by the highest officials in the province, every head of a department, every important functionary, and many minor satellites, until, as was humorously remarked, "the Bar became like the shield of Achilles, thick with bosses."

After some six or eight months the scarcity passed away, and the people were sent back to their homes, a very different set of creatures from those who had come. Well nourished, healthy, and fit, they were, above all, perfectly satisfied with their treatment. I happened to be at the railway station during the few days when they were being despatched under the superintendence of the two university men above mentioned. The people were warm in their farewell greetings. "When we came," said one, "we were afraid, but now if the Sirkar were to tell us to go with you even to Kabul we would go." The Punjabi peasant regards Afghanistan as the least desirable spot on earth for him to visit, so this was about the highest praise he could give.

It was only one proof among many that I have seen in various places, that the type of man produced by our public school and university system attracts the confidence and even affection of different types of

humanity all over the world. Sikhs and Gurkhas, Chinese and Africans, all follow men of this class cheerfully into danger and hardship. Apparently no other nation attracts this confidence. The chief reason must be that it is evident to the people that the English *gentleman* has absolutely no axe of his own to grind, and that he acts not for the aggrandisement of himself but solely for the good of the people over whom he rules. Those of his countrymen who fallaciously impute to him other motives display their own ignorance as well as their malevolence.

We have not yet alluded to one large, though as yet hardly touched, asset in these great canals. The development and transmission of power is one of the features of modern engineering science, and the discovery of cheap power is one of the most eagerly sought after demands of modern commercial and industrial life. Our canals have been made primarily to supply water to the land, but in the flow of that water through channels and over falls there is cheap power which, I venture to think, will be in the near future a most valuable national asset. In Kashmir lately a Canadian officer, who has made a special study of such developments in America, and who successfully applied them in Southern India, has recently utilized the waters of the Jhelum to supply power (20,000 horse-power) on a scale hitherto deemed impossible. It may be that the series of falls, for instance, on the main stream of the Bari Doab Canal will be similarly utilized without interfering with its value as an irrigation canal.

At Peshawar there was a scheme, which may by this time be actually carried out, for utilizing the fall in a small canal which flows close to the station. There is a drop of about 50 ft. in a short distance which would supply power enough to light the whole place with electric light,—no small consideration in a spot where the border thief is so much in evidence, and where shooting the sentries is a national pastime among the tribesmen.

The Malakand Pass, a few years ago the scene of much fierce fighting, is now being pierced by a tunnel which will bring the waters of the Swat River to a barren tract to the south of the Pass. The water passing through the tunnel in its fall is capable of generating power sufficient to supply all the industrial needs of the country for miles round.

Mention of the Frontier recalls the fact that there a canal fulfils a function which, happily, is unnecessary elsewhere. It is a peacemaker, it induces men to turn their swords into ploughshares, it gives them some other occupation than highway robbery. The most conspicuous example of this is the Swat River Canal, which irrigates part of the Peshawar Valley. That valley, an almost circular plain about 40 miles in diameter, is divided into two, roughly, equal parts by the Kabul River and its tributary the Swat. The southern part had from ancient times been well watered and fertile; but the northern part, except for a small strip along the river bed occupied by eight villages, whose lands were always exposed to depredations from the caterans in the neighbouring hills, was a bare and desolate plain. The soil was good enough, and evidence of long bygone prosperity was afforded by the extensive ruins of an old Buddhist monastery which crowns a rocky hill rising abruptly at the eastern side of the plain, ruins of excellent masonry, far superior to anything of Pathan workmanship, and containing sculptures, brought

to light in excavation, which prove the great advance in civilization that must then have prevailed. To the Pathan, however, such sculptures were anathema, idols which no Moslem could regard with tolerance; and as for the ruins, they formed an excellent quarry for stone, but they served no other useful purpose. Meantime the broad plain at the base of the hill and as far as the eight villages mentioned was a wilderness of thorn and coarse weed, a place that no man cared to cultivate, a battle-ground between two clans, kept in check only by the Corps of Guides at Mardan.

It was, I believe, Sir Henry Durand, Lieutenant-Governor of the Punjab, who was himself an engineer officer, as has been already noted, who first, about 1870, conceived the idea of turning the waters of the Swat River over this wilderness. Not an easy task, for the plain is seamed with ravines, and therefore a canal there is necessarily expensive; but if only it could induce the turbulent rivals to lay down their arms and expend their energy on agriculture instead of mutual quarrels, the cost would be money well laid out. Even if the canal paid no percentage at all, it would be worth a trial on this ground alone (as a matter of fact, it now pays a very handsome revenue).

So a scheme was prepared, and in due course of time the usual careful estimates were sanctioned and work begun. The haughty Pathan, of course, refused to have anything to do with the actual construction, and when labour for that purpose was imported from the Punjab, the unfortunate men were promptly massacred in cold blood. However, that sanguinary deed brought down prompt punishment in a way that need not be detailed here, and the work of constructing the canal went on under three young engineer officers, all military men, as it was necessary after the above-mentioned massacre to house all workmen in fortified posts along the line of the canal.

It was no easy task. The country was bare and desolate, the nearest railway station 170 miles distant, the people of the country unfriendly, and respectable contractors would hardly come, except at exorbitant rates, to a country with so evil a reputation. The three officers were obliged to go about armed at all times, and with an escort clattering and jingling behind them. Individually and collectively they were threatened, although it may be questioned whether such threats had the slightest effect on their appetite or slumbers. But gradually the people of the land began to see that the white men meant business, and they had better acquiesce in their presence. This was especially the case with the senior subaltern,* a big burly John Bull, who went through the world with a white bull-dog at his heels, and was not disposed to stand any nonsense from the most truculent Pathan that ever breathed. A man of strict justice and strong common-sense, who would fight if need be, with a resolution like that of his faithful canine companion, but with no desire to do so. (He died, I may mention, about ten years later in Burmah, having served with distinction in at least three campaigns, and having gained one brevet and a D.S.O.). So the Pathan gave up the worrying game and let the sahibs alone.

The works were important, demanding considerable engineering skill, and of course all materials had to be locally obtained. The officers

* Lieut. (afterwards Brevet Major) T. P. Cather, D.S.O.

had to live in small dwellings in the fortified posts above mentioned, where in the summer the heat, unrelieved by any shade or the vestige of any green herb, was terrific. But an occasional week-end spent with the Guides at Mardan gave a little variety and companionship, so that on the whole the life was cheery, though the country was bare and forbidding.

Then the Afghan War broke out. All the engineers on the canal were ordered away, and the work passed into other hands.

A few years ago I revisited that part of the Frontier after some 22 years' absence. I heard that the prosperity of that part of the Peshawar Valley had increased by leaps and bounds, that it was absolutely peaceful, and that the revenue from the canal and the wealth of the country it watered were such that the only regret was that the canal had not been made very much larger.

Much interested, I went one day to the old Buddhist ruins. The hill there was one of the few unaltered landmarks in the country. The road thence from Mardan, in former years a bare and dazzling stretch of drab soil, is now a shady avenue, with a sparkling streamlet flowing alongside. Then came the climb up to the ruins, where I sat and feasted my eyes on the glorious scene below. Far off lay the mountains above the Khyber and the Kohat Pass, with the well-wooded and watered country round Peshawar. That was the same as before. Farther north lay the hills of the Mohmand country, and still farther lay the Malakand Pass and the hills round it, also unchanged. But at my feet lay a beautiful carpet of green waving wheat and barley, stretching for miles to the west and south. The sunlight glinted on a bend of the canal, whose course was clearly traceable by a broad belt of plantation stretching for miles to the mountains, and I was not too far away to hear the musical murmur of the water as it poured over a tiny fall at the head of one of the distributaries. It was a glorious day in early summer, the blue sky overhead was cloudless, and there was every prospect of a splendid harvest. New villages had sprung into existence, and a new generation of tribesmen had been born.

As I gazed, drinking in the lovely scene before me, memories came rushing into my mind of fierce hot nights and days in that very land, when the scorching heat seemed to dry up the very moisture in one's eyeballs, when the shimmer of the desert mirage seemed a mockery, not a prophecy, when the grappling with the difficulties of the work seemed a task almost insuperable, and when the blackguardism of men made success appear more and more hopeless. But there it was—the finished work. To see it with one's eyes was a reward far greater than could be bestowed by rank or ribbons, and I remembered good old Sir Arthur Cotton's words, "Gentlemen, I envy you . . . . Future generations will bless you." With reverence and humility, too, one realized a new truth in the words, "He shall see of the travail of his soul, and shall be satisfied."

It must be remembered that the above three articles on Indian Canals were published originally in 1908, and that consequently many of the improvements, etc., suggested have been since completed.—Ed., *R.E.J.*

NOTICES OF MAGAZINES.

REVUE MILITAIRE SUISSE.

January, 1914.

THE BATTLE OF MORAT.

By Max de Diesbach, Colonel of Infantry.—This battle, which took place towards the end of 1476 against one of the foremost military leaders of the day, Duke Charles of Burgundy, is one of the most memorable ever engaged in by the Swiss. A critical examination of the records, undertaken by Dr. Hans Wattelet in 1888, threw doubt on the description of the battle which, till that date, had always been accepted as correct by historians. His view was substantiated, when in 1892 a contemporary account of the battle, written by the Milanese Ambassador, Panigarola, was discovered. In this article the correct account is given.—(*To be continued*).

THE LEWIS AIR-COOLED MACHINE GUN.

By George Westter Tricoche.—This weapon is fully described, and illustrated by photographs and a plate. It is the invention of Colonel Lewis, of the U.S. Army, and has a single barrel, under which is a cylinder connected to the barrel by a small tube near the muzzle, in which slides a piston. On discharge, a small portion of the gases escapes into the cylinder and drives back the piston which actuates all the gear. The piston is then forced forward again by a spring, and as long as pressure is applied to the trigger the action is entirely automatic. The magazine is rotatory, contains 25 rounds, and can be clipped on its pivot above the breech in 2 seconds. The amount of gas escaping into the cylinder is easily regulated, and allows of firing anything from 400 to 750 rounds a minute. The barrel is surrounded by an aluminium radiator, like a 20-pointed star (less two points cut away to make room for the cylinder) in section. It is enclosed in a jacket open at the breech end, which projects beyond the muzzle. The gas escaping at the muzzle draws in air under the jacket round the radiator, thus cooling the barrel, and considerably lessens the recoil. The temperature of the barrel rapidly rises to 330°, but only attains 440° at the end of 1,000 rounds rapid fire, which is hardly ever likely to be required. The total weight is only 26½ lbs. and the gun can be fired from the shoulder. The projection of the jacket quite extinguishes any flash on discharge. The weapon is very simple, there are only 49 pieces, which can be dismantled in 30 seconds by means of the point of a cartridge. Though designed for use by infantry and cavalry it is particularly adapted for use on aeroplanes. A pilot in the U.S. flying about 500 ft. high at a rate of 50 miles an hour, and holding the gun between his knees, placed 45 rounds out of 50 in an oblong 53 ft. by 9 ft.

INSTRUCTIONS REGARDING FIELDWORKS FOR USE BY INFANTRY.

By Lieut. Decollogny.—This article contains some remarks on the revised issue of the handbook. The teachings of the Russo-Japanese War induced all nations to revise their regulations, and the Swiss instructions were issued in 1912. Stress is laid upon the necessity for entrenching during the attack, but the European nations do not go so far in this direction as the Japanese, possibly for fear that too much attention paid to the spade may check the ardour of the advance. Napoleon's maxim should however be borne in mind "Condemnation of hasty entrenchments encourages a spirit of idleness in the troops."

Objection is taken in a few instances to the wording used, and fault is found with the type section of trench for fire from the sitting position, in that it does not provide sufficient protection; an improved section is suggested. It is laid down that clearing the field of fire and providing range marks are of more importance than the provision of cover. The average distance of obstacles from the firing line in works of defence is prescribed as 50 to 100 metres to avoid damage to them from shells fired at the trench. The Japanese consider that artillery fire has so little effect on obstacles that they should not be more than 30 metres from the firing line, in which position they can be easily defended even on the darkest night. The use of dummy trenches is advocated.—(*To be continued*).

THE REVISED INFANTRY REGULATIONS.

By F.F.—The introduction of the new rifle has necessitated a partial revision of the *Infantry Regulations;* advantage has been taken of this to modify the wording of other paragraphs which was open to misconstruction. This article deals with the latter. The changes are of no great importance, except that the duties of commanders of groups in the firing line are more clearly defined. The writer compares these duties with those laid down in the regulations of other nations.

February, 1914.

THE BATTLE OF MORAT.

This article is concluded. It is of historical interest only.

MACHINE GUNS AND DOG TRACTION.

An account of trials lately made in Belgium of the use of dogs for drawing light vehicles carrying machine guns and their ammunition. The results seem to have been eminently satisfactory, and kennels for a dozen dogs are to be immediately built in the barracks of every infantry regiment, also stud kennels at Beverloo. Several photographs illustrate the article.

OPERATIONS OF THE SERVIAN ARMY.

By A.—A short outline of the mobilization and strength of the Servian Army, and of the strategic concentration, followed by a statement of the strength and stations of the Turkish Western Army. The operations up to and including the Battle of Kumanovo are then sketched. A general map of Macedonia, and one on a larger scale of the battle, are attached.

REGULATIONS FOR FIELDWORKS FOR THE USE OF INFANTRY.

This summary of the new issue of the regulations is concluded and deals with :—(6). Points d'Appui.—To economize troops the defence must be organized as a network of strongly-held localities linked up by more lightly-held curtains. When the enemy is involved in the network, the defenders of the localities will operate against his flanks. The localities must therefore command the neighbouring ground and flank the curtains. The troops allotted to them should live in them. As they will draw the artillery fire of the attack they must be freely provided with bombproof cover by the engineers. The adaptation of localities to the ground is illustrated by sketches which also show arrangements for gorge defence and obstacles. (7). Execution of Works.—Rapid progress is stated to depend on judicious division of labour, on precise orders, and vigorous discipline. Profiles should be progressive, so that works can be improved without demolishing what is already constructed. All ranks must thoroughly understand the use of tools and be ready to use them, and the French regulations emphasize the necessity for breaking in the soldier to their use by constant practice. Special instructions are laid down for working under fire and at night. (8). Revetment is generally necessary, and will consist of sods, sandbags or continuous hurdle work.

Part II. contains rules for the application of the principles of field fortification (i.) in attack, and (ii.) in defence. Copious extracts from the regulations of other nations are quoted. Communications and camps are then dealt with. In appendices are given sketches of the defence of a group of buildings, and of a large village, also tables of proof thicknesses of various materials, sizes and numbers of tools carried, etc.

A.R.R.

RIVISTA DI ARTIGLIERIA E GENIO.

December, 1913.

AUTOCARS FOR FORTRESSES.

The substitution of mechanical traction for that by animals is continually taking place both for commercial and military purposes.

A valuable article on this subject appears in the *Artilleristische Monatschefte*.

A consideration of the distances that can be traversed by motors by the small number of quadrupeds that can be assigned to a fortress and by the immense quantities of forage that are necessary for the maintenance shows clearly the value of mechanical traction. The author is evidently not by any means in favour of ancient methods and states that the mechanical traction of field artillery is not only possible, but would have been resorted to had the military administration gone thoroughly into the question.

In fact all the objections to motor artillery are founded on the presupposition that the motors should be built on the same lines as motors

which we now see constructed for entirely different purposes. Considering that the problem of using motor traction for the field army has remained in a state of somnolence, it is not to be wondered at if the employment of mechanical traction for fortresses has been entirely disregarded.

Fortresses are from a tactical point of view considered superfluous, or at least more or less inconvenient, and questions with reference to them seem always to be considered last.

But fortresses cannot be improvised. If at the last moment the garrison requires to be reinforced, it is possible to throw in troops from the first line, but it is not possible then to improvise armour for the guns, or masonry cemented works for their protection in the positions suggested by the enemy's fire. All this should be ready. Every fortress at the moment of the declaration of war should have at its disposal all arms and material either offensive or defensive.

All forms of defence have their weak points, and this is especially true in fortress warfare. The defence of a fortress is, from the commencement of the attack, subject to difficulties if it is not provided with all the technical advantages that it may be possible to provide.

One of the means for facilitating the defence of a fortress consists in the ample employment of mechanical traction.

Mechanical Traction for the Ordnance.—For all the ordnance in a fortress, armour-protected or otherwise, a rapid means of transfer in all directions should be assured. This can be attained not only by the special construction of the carriage, but also by a systematic preparation of the means of traction. In the great fortresses difficulty is always found in moving the pieces of the reserve artillery, owing to the employment of horses from the park; the change from one front to another is a work of much labour, and the batteries are then only able to come in to action slowly with exhausted horses and tired drivers.

The defence has become more and more difficult and but one resource only remains, viz.:—to oppose to the mobility of the attack a similar mobility of the defence. To-day when automobilism holds so conspicuous a place, there can be no doubt that the satisfactory solution should be in the employment of mechanical traction. This idea has been used only in the entrenched camp at Lisbon, where up to the end of 1904 heavy motor artillery is stated to have been adopted. Mention is made of a train of four pieces or of four caissons coupled together and drawn by a single motor. One point also has to be remembered, that, whilst in warfare in the field account has to be taken of a network of roads in an unknown condition and of artillery that is able to move outside the roads and to overcome obstacles, in the fortresses the roads are not only perfectly known but can be prepared wherever necessary, so that the employment of mechanical traction is facilitated in an extraordinary manner. The tactical advantages are also evident. Suppose, for example, the distance of the works from the town to be about 8 k.m. (which represents the least distance not to expose the city to the fire of the attack), and the diameter of the habitable part of the town to be 10 k.m., to move the reserve artillery from one of the encircling works

to a position diametrically opposite, the distance to be traversed would be 8+10+8=26 k.m.; drawn by horses this would take about five or six hours, while with mechanical traction and with very limited speed the time would be about a couple of hours. The depth of the column is also less, and there is no anxiety about the exhaustion of the horses or the fatigue of the men. The tactical value of a battery thus moved is much increased.

The question of "motor trains" has not been sufficiently studied. It would be desirable to construct motor trains capable of being used for all kinds of guns and mortars. And it is easy to imagine trains with carriages, which would go a long way towards solving the difficult problem of transport of ammunition. The problem of the initial movements by motor traction of siege artillery for the investment of a place is also interesting. In this case the movement of heavy artillery would have great tactical value, as it would be able to act on one point of a fortress or on another.

Another important circumstance in the adoption of mechanical traction for the reserve artillery has to be considered. Any reduction of animals for the park is very desirable. It is difficult to supply all the horses that are necessary for the needs of a fortress. Every horse or other quadruped is a consumer and requires to be provided daily with about 6 kilogrammes of oats which, for the provisioning of the whole fortress, represents several tons. The motors of course consume benzine, but in comparison with forage rations the calculation is relatively much less.

Mechanical Traction for the Ammunition Wagons.—Generally speaking it is not difficult to provide the ammunition in the first fire positions, as this is supplied from the magazines of the place; when this becomes difficult it is brought from the batteries which are replenished from the rear when circumstances require. During the first period of the artillery strife, owing to the ground of the fortress not being so much swept by the artillery fire as later on, the difficulties of replenishing the ammunition can be easily overcome; and in addition to this only a limited number of pieces are in use and less ammunition is therefore expended. The German regulations lay down that the ammunition for the foot artillery should be distributed in such a manner that it can be sent *rapidly in all directions*. For the transport of ammunition it is especially necessary to have recourse to the "binaries" which should unite the magazines with their corresponding fire positions, and these with the railway network of the fortress. The superiority of fire depends upon the number of pieces, and on the weight of the projectiles fired against the enemy, and to ensure this the essential duty of the defence is to arrange for the greatest possible and most rapid distribution of ammunition in every direction.

The employment of mechanical traction for the artillery and the ammunition furnishes the means.

Armoured Autocars.—One of the characteristic creations of modern military science is the armoured automobile which carries a cannon or a mitrailleuse. It has arisen in consequence of the evolution of aeronavigation. It is required to combine speed with force, and to be able

to follow rapidly the aerial observer, and compel him by its fire to descend to the earth.

The idea, however, of placing a gun on an armoured carriage designed for rapid motion is, in the author's opinion, erroneous since it diminishes the speed which is its first essential. It is difficult to imagine a tactical situation in which the use of an armoured automobile would play a part; but even admitting an isolated case, it would scarcely justify the adoption of a special gun.

The defenders of a fortress can oppose to the aerial exploration of the enemy the fire of his guns, but the employment of armoured automobiles in the limited space of a fortress would in the author's opinion be useless.

FRANCE.

Siege Exercises.—A circular from the French War Minister decrees that siege exercises will be carried on at Epinal in 1914. Within a sector of that strong place a methodical development of all siege operations will take place, but there will be no firing with projectiles. The exercises will last from 10 to 12 days, in addition to the days for the movements and concentration of the troops, and for the preparatory works of installation.

The artillery and engineer troops assigned to the siege equipments and parks for the attack, and those assigned for the defence of the place will take part in the exercises, as well as one infantry division; two infantry regiments stationed at Epinal and Toul and reserve formations; and one cavalry regiment.

E. T. THACKERAY.

CORRESPONDENCE.

MASONRY ARCHES.

SIR,

"One of the Average R.E. Officers" may rest assured that, if a masonry or brick arch, and its abutments, conform to Trautwine's empirical rules, it will be safe under the ordinary mechanical transport of the present day, provided that the workmanship and the material of the bridge are sound.

The allowance that should be made in the case of old bridges, with badly built arch rings, decayed stone and perished mortar joints, must be a matter of judgment in each particular case; and in some cases the abutments may be unduly weak; a point not easy to determine by casual inspection.

In case your correspondent does not know Trautwine's rules, I append them.

Yours truly,
"ANOTHER AVERAGE R.E. OFFICER."

The Editor, *R.E. Journal.*

RULES FOR DETERMINING THE PROPORTIONS OF ARCHES AND THEIR ABUTMENTS.

These rules are extracted from *Trautwine's Pocket Book.* Their author makes the following note on them:—

> "Inasmuch as the rules which we give for arches and abutments are entirely novel it may not be amiss to state that they are not altogether empirical, but are based upon accurate drawings and calculations made by the writer of lines of pressure, etc., of arches from 1 to 300-ft. span and of every rise from a semi-circle to $\frac{1}{5}$ of the span. From these drawings he endeavoured to find proportions which, although they might not endure the test of strict criticism, would still apply to all the cases with an accuracy sufficient for ordinary practical purposes."

To find the depth of keystone for first-class stone arches, circular or elliptic.

$$\text{Depth of key in feet} = \frac{\sqrt{\text{rad.} + \text{half span}}}{4} + 0{\cdot}2 \text{ ft.}$$

For second-class work increase $\frac{1}{8}$ part; for brick or fair rubble about $\frac{1}{4}$.

For elliptic arches the radius may be taken as that of a circle which will approximately coincide with the soffit curve.

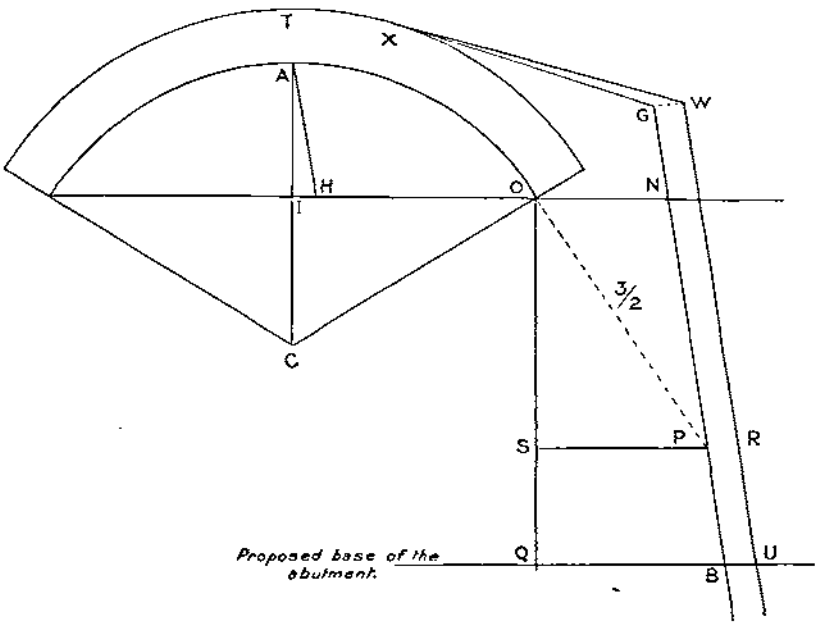
To determine the proportions of abutments.

Thickness ON of abutment at springing $\frac{\text{rad. in ft.}}{5}+\frac{\text{rise in ft.}}{10}+2$ ft.

Mark the point N thus obtained. From centre of span I lay off IH=$\frac{1}{24}$ span. Join AH. Through N draw GNB parallel to AH. Make GN equal to half the entire height of the arch IT. From G draw tangent GX which will mark the top of the masonry filling.

Through O draw OP at inclination of $\frac{3}{2}$ to the vertical. If P lies below the proposed base (*i.e.*, if the height of abutment does not exceed 1½ times the base) GNB is the back line of the abutment. If not add thickness PR=$\frac{1}{4}$ SQ, and through R draw URW parallel to AH as before. If, after this addition the base QU of the abutment is less than *one-half* its total height (which very rarely happens), then make the base one-half the height and draw a back line parallel to AH as before.

These additional thicknesses are to provide against earth thrusts behind the abutment, rather than against the thrust of the arch, and would not be applied in abutment piers. In abutment piers however appearance has to be considered in deciding their thickness.



All the abutments thus found will be safe, *given good workmanship and materials*, without any dependence on wing walls and no matter how high the embankment extends. If the bridge is so narrow as to bring wing walls close together, so that they will afford material support, the abutments may be made thinner at the discretion of the engineer. Reductions in dimensions however should be made with caution. This method applies equally to the smallest culvert and to the largest bridge, whatever may be the proportions of span and rise, and whatever the method of filling above the arch.

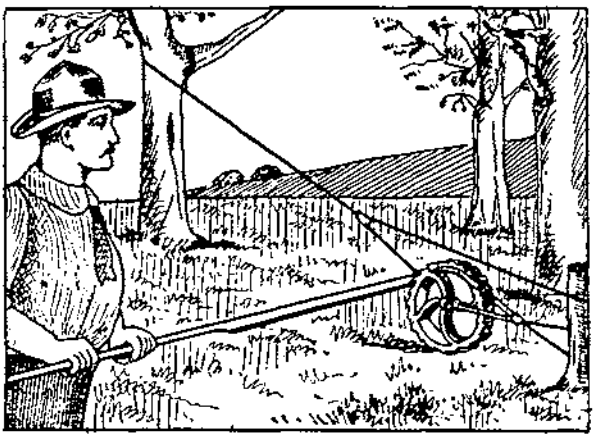
THE "FOREST DEVIL."

SIR,

In the March number of the *Journal* there appears (p. 130) a brief description of the forest devil, together with a plate (p. 131).

On the figures and diagram given, I cannot work out 80* tons pull on the chain from the devil to the tree to be pulled down, if the chain is attached at the root, or within 1 ft. of the ground.

I know another form of forest devil very well, and have used it often in big clearances in Australia. I enclose an advt. sketch of a somewhat similar pattern.



It will be seen that the "pull" is obtained by a combination of lever, capstan, and 2/1 pulley, with the "W" end of the tackle made fast to the pulled tree some 8 or 10 ft. from the ground.

The form I have had to deal with consists of a lever-worked winch, hauling in on the running end of a whip-on-whip, which differs slightly from the enclosed sketch.

Given any ordinary crab winch with a pawl catch, it is easy to rig a forest devil, using something like ⅞-in. steel wire rope for the main pull, and a bullock chain for anchorage.

Yours faithfully,

CECIL H. FOOTT, *Major*,
Royal Australian Engineers.

R.N. War College, Portsmouth.

The Editor, *R.E. Journal.*

* This was due to a clerical error and the amount was intended for 8 tons.—[ED., *R.E.J.*].

UTILITY AND ECONOMY . . .

THE general utility and economy of gas appliances are now widely recognized; gas is being installed daily in buildings of every kind throughout the country.

In view of these facts, architects, engineers, and builders would be well advised to anticipate the requirements of their clients by making provision for gas supply, when plans and specifications are under consideration, so that points shall be readily available when required.

Gas-equipment is likely to be desired for Cookers, Water-Heaters, Lighting, and Fires, as well as for Engine Power and Furnaces.

By preparing for gas installation, all after-disturbance can be avoided.

Pamphlet U 311, deals more fully with this question. Can we send you a copy, or serve you in any other way? The British Commercial Gas Association, 47, Victoria Street, London, S.W.