R·E

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PREFACE.

At the last Annual General Corps Meeting it was decided that the *R.E. Occasional Papers* should only be issued in pamphlet form to those officers who should signify their wish so to receive them, and that the general issue should be in the form of bound volumes of the *Professional Papers*. These volumes are issued at irregular intervals as sufficient papers accumulate, and are published by Mr. Edward Stanford, of 55, Charing Cross. A very small minority of the officers of the Corps have applied for the papers as they first appear in pamphlet form, and consequently, to most officers the present volume (VI.) will be new, and will be found to contain matter of considerable and varied interest.

In this volume are included two Prize Essays—that for 1877, and that for the present year—and a word of explanation is here necessary. The Essay for 1877, by Lieut.-Colonel R. Harrison, R.E., to whom the Gold Medal for that year was awarded, was not printed at the time, as there were official objections to publishing some parts of it; these objections have not now the same force, and, some excisions having been made, permission has been received to print it with the omissions marked by asterisks.

None of the Essays received for the year 1878 were recommended by the Referees to receive the Gold Medal, but three of them, which were considered of equal merit, were commended, and an abstract of these was published in Vol. III. of the present series of the *Professional Papers*.

Two Essays only were sent in for 1879, and again for 1880, and in neither of these years did the Referees recommend the award of the Medal.

Under these circumstances, and after much discussion, it was decided at the Annual General Corps Meeting held in 1880, to discontinue Prize Essays when those for the year 1881 should have been received.

Three Essays were received for 1881; the Gold Medal was awarded to Lieut. R. da Costa Porter, R.E., and his Essay, which is the last of the R.E. Prize Essays, is published in the present volume.

ROBT. H. VETCH, Major, R.E.,

Secretary, R.E. Institute, and Editor.

December, 1881.

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LIST OF PLATES AND TABLES.

ERRATA.

Page 111, second line from the bottom, *for* "Du" *read* "De"
,, 126, sixth line *for* "descrepancies" *read* "discrepancies"
,, 135, first line, *for* "*later*" *read* "*lateral*"
,, ,, twenty-first line, *for* "adopted" *read* "adapted"
,, 137, eighteenth line, *for* "$90° - \frac{o}{2}$" *read* "$90° - \frac{c}{2}$"
,, 139, fourth line, *for* "Girfillen" *read* "Gilfillan"
,, 141, twenty-third line, *for* "heights" *read* "weights"

PAPER I.

REPORT UPON AN

ENGINEER FIELD PARK FOR A DIVISION,

BY MAJOR-GENERAL F. R. MAUNSELL, R.E.

Communicated by the Deputy Adjutant General, Royal Engineers.

1.—It seems convenient to divide the subject into three headings, namely, Material, Personnel, and Transport, prefixed by a statement of the general principles upon which the organisation should be based.

2.—The Park should be arranged into Advanced and Reserved—first and second if convenient—which principle indeed seems applicable to all sound military organisation; also each of these divisions should be estimated with a view to facilitating a separation into two detachments.

3.—The stores should be calculated as mainly for the infantry when employed on works under the Engineers, their own regimental equipment tools being only used for regimental requirements and work under regimental supervision, a moderate allowance being added to meet the demand of other branches and of departments, which are constantly made, especially in standing camps. They should also be calculated to supply deficiencies or extra wants of the Sappers and of Infantry Regiments.

4.—There should be a supply depôt at the base.

5.—It should be understood that the equipment laid down is that generally suitable and to be adhered to, but as the nature and locality of the operations contemplated may sometimes require modifications, both for efficiency and economy, some consideration should generally be given for each case, and any necessary deviation made.

6.—It is important, therefore, that the Engineer officer in command, and his park staff, should be appointed and fully informed in good time, so as to be able to consider the requirements and arrangements necessary. Thus, bridge stores, &c., might be necessary as the obstacles might include rivers to cross; a speciality in transport might also require pre-arrangement. The absence of any element of Park organisation in peace renders this early war organisation particularly important.

7.—In this report the Sapper Equipment and Park are not considered, except in so far as accepting the necessity of supplying some of their probable wants affects them. I would, however, here note the desirability of establishing lighter or more uniform sets of tools and boxes for Sappers. Picks and shovels are not sufficiently uniform nor light.

8.—*With regard to Material.* It is highly desirable that the tools and apparatus should be of first-class quality; it is false economy, or worse, to transport inferior stuff hundreds of miles, as it often has to be discarded, or gets broken or useless. The tools supplied from Arsenals are generally of good quality and form, though sometimes complained of, the camel boxes, however, are too large and heavy. I would note here that it is very desirable that a supply of Bickford's detonating fuzes, and of his instantaneous fuze, should be obtained from England; these things are most useful for demolitions, and efficient articles of this sort have never yet been received.

9.—The annexed table shows the detail of the stores recommended, with a detail told off as Advanced Equipment. I have thought it convenient to divide the stores into sets as far as feasible.

10.—There may seem to be a large quantity of stores in this list, but for general service it would not be possible to omit stores which might only be useful in some cases; of course some of these might be omitted in special cases.

11.—There are, indeed, sundry special stores or equipment which might be required in addition to those in this list, but which should not form a necessary part of every Park, such as bridging materials, pontoons, trussed beams, planks, iron-band gabions, &c., these should be kept in Arsenals ready for issue on demand. For the operations of the 1st Division (of the Peshawar Valley Field Force) a special bridging equipment was constructed, and is recommended as a regular equipment, the pattern to be taken from the Sappers, namely, portable trussed road-bearers, supported on telegraph iron posts as trestles; they were made in pieces for transport on camels and proved most valuable; the timber of the country was not generally very strong, being liable to break very unaccountably. Cable, or hawsers, including wire rope, with traveller rollers, &c., are very useful stores for aiding in crossing rivers by flying and warping processes, and should be in Arsenals. A list of such is appended.

12.—The requirements of service are sometimes so multifarious that they cannot always be met without local purchases; charcoal, &c., requires replenishing, civil labour has often to be paid for, &c., so that it is necessary to arrange for advances from the treasure chest and to keep an account. It would be advisable to start with a small amount of cash to anticipate difficulties.

13.—Regarding the tools and stores best suited for British and Native working parties, the annexed table indicates what I consider a serviceable equipment; a few implements for removing obstructions and also for lining and measuring are included. It should be in charge of intelligent men who understand somewhat of lining out and measuring. This touches the need of having men trained as Pioneers or Sappers—I think there should be 10 or 12 in each company. I think it also important (and this I submitted to Head Quarters before the march of the Division I was attached to, as it seemed a matter of general and not only divisional concern), that regiments should keep these things in order themselves. Of course where there is a Park and time allows they can be then repaired, but this is not always the case, and it always takes time, and as regiments have armorers and artizans, who, though few, are generally of higher qualifications than those of Sappers or of the Park, it seems very advisable that some spare material should accompany them, and that they should be authorized to purchase whatever is necessary.

14.—Tents suitable to mule transport should be substituted, should a pattern be ever approved. Some of the stores requiring shelter when in use, or opened out, &c., a small amount of tentage has been allowed for them.

15.—*With regard to the Personnel.* There should be an officer definitely appointed to the charge of the Park; there is a great deal to do, the work is very onerous and generally tedious and uninteresting compared to other work, so that no one would take it optionally. He should receive a special and commensurate staff allowance, and be responsible for all stores, returns, &c. The frequent changes which were unavoidable with the 1st Division might have been very detrimental. I consider that the Superintendent of the Field Park should receive a staff allowance of Rupees 300, also horse and office allowance.

16.—It would be quite feasible under ordinary circumstances for the Brigade Major to have charge of the Park with a junior officer to assist when office duty calls him away, but it is of course better to have things complete in war; it is generally better economy.

17.—As assistant to him 2 British Park Serjeants, or rather, 1 Warrant Officer and 1 Park Serjeant would generally suffice; for these, too, some arrangement for their allowance is wanted. Vexatious difficulties have been made as to the allowances of the British Park Serjeants employed in the 1st Division; these men had very hard work, they were constantly employed and should have received pay commensurate with their deserts; the last month's pay they drew on Public Works from which they joined was Rupees 85 and horse allowance. A staff allowance of Rupees 50 and horse allowance would be the least they could fairly be allotted. Officers join from works and get the whole of their Public Works allowance made up, and this rule might be fairly taken as a guide for their assistants. Difficulty and delay occurred in obtaining these men.

18.—For the Native staff two intelligent non-commissioned officers are required to keep the accounts, one of money and one of stores, also 2 (two) lance-naicks, one for general duty and one for transport duty. These were obtained from the Sappers, but I regretted afterwards having done this, as they were much wanted in their companies.

19.—No other fighting men seem necessary, but the usual Line guard would be necessary.

20.—The scale proposed for establishment is shewn in the annexed table. No difficulty existed about their pay because it was made a charge in the Park accounts, which however, might be objected to by a critical pay department. A difficulty occurred in obtaining these men. Nothing efficient could be obtained near at hand and the men were finally got from a long distance, and after much delay. The establishment should be properly armed with cutlasses or tulwars, which they understand how to use.

21.—The transport drivers for the advanced equipments on mules should be thorough good muleteers, and exclusively under the control of, and paid, rationed, &c., by the regiments or departments to which they are attached, as regular regimental establishments. I think that a portion, if not all (as also those for ammunition), mules and muleteers should be permanent establishments on the rolls of regiments, and that all others added should be also borne on the same rolls. For the transport taken up on the hiring system the usual number of drivers seems enough; an addition, to allow of the owners tending their own animals, should be made. There has often been difficulty about the pay and rations of these men and the rations of their animals on service, *i.e.*, of those attached to the Engineer Brigade, chiefly owing to there not being any special or fixed commissariat officer or official of any sort for that portion of the force—very likely due to the want of any definite organisation being laid down.

22.—Arrangements are required to provide all the establishments at any early date. Indeed the same might be said of the officers and soldiers; they are all most particularly required in the preparation and first movements of a force. The difficulty and delay in this matter in the late operations was a very vexatious hindrance to works and to efficiency, and requiring great personal exertions (which might have been better directed) to improvise make-shifts. The Sappers should not be counted upon to furnish Park Serjeants or Native Staff, as they have not sufficient efficient men generally even for their own requirements, but they should be referred to in case they have any available. The Park Serjeants should be available from R.E., D.P.W., men, arrangements being made in that department to provide fit men. The Native Staff could be obtained from infantry regiments. This plan of getting men for the D.P.W. is not good under present circumstances; of 8 or 9 men nominated to be chosen from, hardly any were really available or fit for the work.

23.—It should be noted here that the establishment given is what would be generally enough, but that circumstances may require extensive additions. During the late operations I obtained a good many good artisans from British regiments, and a good many bad ones from the country for the extensive work required in the Park.

24.—The Staff or Brigade Office being intimately connected with the Park business, the Brigade Staff-Serjeant having to see to the telling off of the working parties, &c., and the other officials also being associated, they should be classed and quartered together.

25.—The *personnel*, as above, is assumed as to be improvised at the time of the mobilisation of the Park, and without encroaching upon the existing strength or organisation of other services—especially of the Sappers—for that Corps is certainly too weak for its ordinary duties; but it is most desirable that there should be a special and separate arrangement for this Park duty. This should exist in the form of a nucleus or cadre of men in peace, ready to take up the duty under military surveillance, and in the discharge of the very duties required of the men in the field. The only feasible plan of ensuring a serviceable system, seems to me to be to establish an efficient cadre at the depôt of the Sappers, where they should have the necessary practice, and have lists of stores contained in a Field Park. This cadre—say 2 British Serjeants, 2 Native N.C.O. and 2 Lance N.C.O—should be in addition to the strength of the Sappers. When detached for Park duties with a Division, they should be settled up with as to pay, &c., before starting, and thereafter they should be settled with under the orders of the C.R.E. of the Division to which they are attached. As to whether any transport cadre should exist depends on the scheme (believed to be under consideration) for army transport.

26.—Circumstances, such as extensive cantonments, &c., sometimes require extensive additions of officers, establishment, stores, &c. These, of course, are not taken into consideration here.

27.—*With regard to the Transport.* Except for the difficulties in getting over road obstacles, the advantage of wheel transport is very great in saving delays and labour in loading, unloading, dividing the stores into numerous parcels, &c. Against an exclusive mule transport is the inability to carry some of the heavier stores. Camels can carry these, but mules have not sufficient power. It is desirable, however, that a proportion of mules should be attached in all cases, so that a light advanced equipment might be sent, should it be required to move rapidly over bad ground, and this has been allowed for in the table annexed. Such an equipment was told off for the advance on Kabul. In case the road difficulties are great, a large proportion of mules should be used, but camels should be used for the main reserve. If good carts are available and suitable to the country, they should be used for a portion of the stores.

28.—A light cart was approved two years ago for Sapper equipment, and some were found very serviceable during the late campaign; having springs, they made good ambulance carts on a certain occasion. The carts weighed 9 maunds—half the weight of a native cart. They were intended to contain 10 to 12 maunds of stores, and were drawn by 1 pair of train bullocks to each. I would have 24 (twenty-four), or so, of these maintained in each Arsenal for Engineer Field Park stores. A still lighter cart, to be drawn by one horse, or mule, has been proposed by me for the Field Telegraph Train, which might also be usefully adopted if it should be approved of.

29.—For the transport of the implements with British and Native regiments an advanced proportion should be on mules with Sapper kujawahs (the new pattern adopted under No. 1021 S. of 28th October, 1878, from Secretary to Government to Quarter-Master-General, not being suitable for the field, for this reason, namely, that the helves of picks cannot be made interchangeable, and much delay is occasioned by fitting, and if they are cut for each fitting they soon become unserviceable), for these tools should be available for immediate use, and these mules (or at least a portion) should be permanently with regiments. The rest of the tools might follow on any suitable or obtainable transport—mules, camels, or light carts; *vide* also para. 25 above.

30.—An establishment of this description, with a demolition, &c., equipment, was got up during this campaign for Sapper companies, and proved of great service. Had it been permanent instead of being improvised, the advantage to the public service would have been more marked.

31.—I am not aware whether any revised sytem of transport is under consideration which would affect the matter under report, so that I do not see any necessity, under present circumstances and organisation, to attempt to define any particular system for Park transport, except the ensuring that it shall be forthcoming when wanted, and for this no doubt a proportion of mules should be maintained; *vide* para. 25 above.

(*Signed*) F. R. MAUNSELL, MAJOR-GENERAL, R.E.,
late Commanding R.E., 1st Division, P.V.F.F.

Table showing detail of Engineer Field Park, also of Equipment for each Regiment, of a Division.

(General List).

Description.	Weight of each.	Engineer Field Park.				British Regiment.				Native Regiment.			
		Total.		Advanced Portion.		Total.		Advanced Portion.		Total.		Advanced Portion.	
		No.	Weight.	No.	Weight.	No.	Weight.	No.	Weight.	No.	Weight.	No.	Weight.
Intrenching and Mining Tools.	M. S.		M. S.		M. S.		M. S.		M. S.		M. S.		M. S.
Bags, sand, light...	⅜	10,000	93 30	1,000	9 15	400	3 30	200	1 35	400	3 30	200	1 35
Barrows, mining	22	2	1 4	...	...	...	...	...	...	...	...	...	...
Buckets, canvas, mining	1½	4	6	...	...	...	...	...	...	...	...	...	...
Knives, gabion	⅛	60	7½	8	1	...	...	...	...	...	...	...	...
Ladders, rope, mining	5	4	20	...	...	...	...	...	...	...	...	...	...
Levels, field	2	6	12	...	...	...	...	...	...	...	...	...	...
Lines, log ... ... skeins	¾	40	30	8	6	2	6	...	...	2	1½	2	1½
Mallets, picket	1½	10	15	4	6	4	6	2	3	4	6	2	3
Pickets ... ... bundles	1	10	10	4	4	4	4	2	3	4	4	2	3
Reels, hand, with line	1½	5	7½	...	...	...	...	...	...	...	...	...	...
Rods, measuring, half 10′ and half 6′	1	20	20	4	4	4	4	2	2	4	4	2	2
Tape, tracing ... ... bundles	2	12	24	...	...	...	...	...	...	...	...	...	...
,, measuring 100′	¾	12	9	4	3	2	1½	1	¾	1	¾	1	¾
Tools, axes, felling, American, ...	2	100	5	5	10	16	32	6	12	16	32	6	12
,, pick	5	1,600	200	200	25	160	20	80	10	80	10	10	1 10
,, billhooks or kukeries ...	1¼	100	3 5	10	12	50	1 22	10	12	50	1 22	10	12
,, hand spikes, *vide foot note*	5	20	2 20	4	20	4	20	4	20	4	20	4	20
,, hatchets	1	100	2 20	6	6	16	16	4	4	16	16	4	4
,, helves, spare	1	1,000	25	20	20	50	1 10	10	10	50	1 10	10	10
,, phourahs	3½	500	43 30	50	4 16	...	...	...	...	100	8 30	30	2 25
,, shovels	2¾	1,600	110	200	13 30	160	11	80	5 20	60	4 5	10	28
,, spades	2¾	500	34 15	...	...	60	4 5	20	1 15	20	1 15	10	27
,, sickles	¾	100	1 35	10	8	20	15	10	8	20	15	10	8
Total weight ...	...	...	527 0	...	55 1	...	44 11½	...	20 24¾	...	33 11¼	...	9 1¼

8

Artificer's and other Tools, &c., in sets.													
Sets													
Carpenter's, Sapper scale ...	2 35	3	8 25	1	2 35								
Smith's	3 20	2	7	...	2								
Saddler's	12	1	12	1	12								
Field Forge	2 20	1	2 20	...	1								
Soldering and Tinsmith's, Field Park scale	1 16	1	1 16	...	...								
Demolition and blasting ...	42 30	1	42 30	...	6 36½								
Road making and Mason's ...	34 18¼	1	34 18¼	...	5 25¼	...	3 29	...	1 34½	...	3 29	...	1 34½
Stationery	30	1	30	...	10								
Surveying Instruments ...	3 36	1	3 36	...	18								
Total weight ...	...	...	101 27	...	19 17	...	3 29	...	1 34½	...	3 29	...	1 34½
Miscellaneous.													
Adzes, country	2	20	1	6	12								
Barrows, wheel (half in pieces) ...	22	8	4 16	...	...								
Baskets	¾	400	7 20	...	...								
Blocks, double, with tackle	7	4	28	2	14								
,, single	5	4	20	2	10								
Candles	1 1	5	5	...	...								
Charcoal	1	4	4	1	1								
Dogs-iron	1	50	1 1	...	...								
Glue	1	5	5	...	...								
Grapnels	1½	6	9	...	...								
Grindstones, 18″	1 10	2	2 20	...	...								
Hides, bullock	1¼	8	10	...	...								
Iron, round and bar	1	6	6	1	1								
Jacks, lifting	18	1	18	...	...								
Ladders, scaling, (3 lengths, each 8′ long), ...	1	30	30	...	...								
Lanterns	1¼	6	7½	...	...								
Line, ratline ... ... yards	...	100	1	...	...								
Matches ... ... boxes	...	24	½	6	...								
,, Vesuvians ... ... ,,	...	24	½	6	...								
Nails of sorts ... ... mds.	1	2	2	¼	10								
Carried over ...	...	...	62 0¼	...	3 6								

Table showing detail of Engineer Field Park, also for each Regiment of a Division.
(General List, *Continued.*)

Description.	Weight of each.	Engineer Field Park. Total. No.	Engineer Field Park. Total. Weight.	Engineer Field Park. Advanced Portion. No.	Engineer Field Park. Advanced Portion. Weight.	British Regiment. Total. No.	British Regiment. Total. Weight.	British Regiment. Advanced Portion. No.	British Regiment. Advanced Portion. Weight.	Native Regiment. Total. No.	Native Regiment. Total. Weight.	Native Regiment. Advanced Portion. No.	Native Regiment. Advanced Portion. Weight.
Miscellaneous (continued).	M. S.		M. S.		M. S.		M. S.		M. S.		M. S.		M. S.
Brought forward ...	...	...	62 0½	...	3 6								
Needles, sail	...	20	...	...	...								
Oil ... ... gallons	...	2	4	...	...								
Paint, mixed ... ... seers	...	10	...	...	...								
Rope, drag, 18', heavy ... ... pairs	10½	4	1 2	2	21								
,, Manilla, 3" ... fathoms	2	200	4	100	2								
,, ,, 1½" ... ... ,,	30	200	1 20	200	...								
,, wire, 1½" ... ... feet	...	1,000	5	...	...								
Saws, cross-cut, European	3½	2	7	...	...								
,, hand, country	1	20	20	2	2								
,, ,, Europe	1	30	30	3	3								
,, pit, country	5	2	10	...	...								
Scales, ... sets	} ...	} 1	} 1	...	...								
,, copper ... ... ,,		1											
Screws	1	20	20	...	1½								
Spikes, marline	½	4	2	2	1								
Steel... ... ... seers	1	20	20	...	2½								
Thermometer	...	2	½	...	...								
Twine, hemp, country ... ... seers	1	20	20	...	...								
,, munj ... ... mds.	1	6	6	...	...								
Wire, iron, (not larger than Indian gauge 12) ... ... miles	2	1	2	¼	20								
Special.													
Bridge stores, trussed road bearer 2' long...	3 20	10	35	...	...								
Planks, 10' long	20	50	25	...	...								
Total weight ...	...	...	145 36	...	6 17								

Package, Tents, &c.													
Boxes, Camel ... ... pairs	2 5	4	8 20	...	...	...	...	...	...	...	...	...	...
Boxes, Mule ... ... ,,	26	8	5 8	2	1 12	...	...	...	...	...	...	...	...
Kujawahs, Camel	1 11	10	12 30	...	...	...	...	...	...	...	...	...	...
,, Mule, Sapper pattern, prs.	10	10	2 20	4	1	6	1 20	4	1 0	4	1 0	3	30
Pawlins, Camel	6	40	6	...	...	...	...	...	...	...	...	...	...
,, Mule	4	40	4	8	32	...	...	...	...	...	...	...	...
Tables, Office	12	3	36	1	12	...	...	...	...	...	...	...	...
Stools	2	4	8	2	4	...	...	...	...	...	...	...	...
Tents, European, Private	11	1	11	...	...	...	...	...	...	...	...	...	...
Sepoy or Lascar Pals	3 20	6	21	2	6 20	...	...	...	...	...	...	...	...
Follower's Pals	20	6	3	6	3	...	...	...	...	...	...	...	...
Total Weight, ...	...	...	75 2	...	13	...	1 20	...	1 0	...	1 0	...	30
Abstract of weight. Intrenching and Mining Tools	...	...	527	...	55 1	...	44 11¾	...	20 25	...	33 10	...	8 32¾
Artificer and other sets... ...	...	...	101 27	...	19 27	...	3 29	...	1 34½	...	3 29	...	1 34½
Miscellaneous	...	...	145 36	...	7 3	...	...	...	...	...	...	...	...
Package, Tents, &c.	...	...	75 2	...	13	...	1 20	...	1 0	...	1 0	...	30
Grand Total Weight, ...	...	...	849 25	...	94 31	...	49 20¾	...	23 19½	...	37 39	...	11 17¼

Hand spikes should be shod with iron so as to be usable as crowbars.

A rope made of hill palm or putha is very strong and useful. 4 maunds might be added for trans-Indus operations.

Spare ends for measuring tapes should be added, 2 to each tape with brass ring and 5 feet tape, as this part often gets destroyed.

Powder should be kept with Ordnance Park.

Table showing detail of Engineer Field Park, also Equipment for each Regiment, of a Division.

(Detail of Field Park Sets).

Description.	Weight of each.	Engineer Field Park. Total.		Engineer Field Park. Advanced Portion.		British Regiment. Total.		British Regiment. Advanced Portion.		Native Regiment. Total.		Native Regiment. Advanced Portion.	
		No.	Weight.	No.	Weight.	No.	Weight.	No.	Weight.	No.	Weight.	No.	Weight.
Soldering and Tin-smith's Tools—set.	M. S.		M. S.		M. S.		M. S.		M. S.		M. S.		M. S.
Anvils, Tinman's	5	1	5	...	...								
Borax	...	...	4	...	...								
Brass	...	...	10	...	...								
File	...	1	¾	...	...								
Hammers, hand	¾	1	¾	...	...								
" jointing	1	1	1	...	...								
Lead	...	...	4	...	...								
Mallet	...	1	1	...	...								
Resin	...	...	5	...	...								
Sal Ammoniac	...	...	2	...	...								
Shears	1½	1	1½	...	...								
Soldering iron	...	1	2	...	...								
Tin ... ... block	...	...	4	...	...								
" ... ... sheets	...	...	10	...	...								
Zinc	...	...	5	...	...								
Total weight ...	...	...	1 16	..	...								
Demolition, Blasting, &c.—set.													
Detonators, Bickford's ... ... boxes	5	5	25	1	5								
" Electric ... ... "	5½	5	27½	1	5½								
Funnels, copper	¾	2	1½	1	¾								
Fuze, Bickford's ... fathoms	...	200	25	50	6¼								
" instantaneous "	...	200	25	50	6¼								

Gun cotton ... ... lbs.	...	1,000	12 20	100	1 10								
Matches ... ... boxes	...	24	⅓	6	...								
,, Vesuvian ... ... ,,	...	24	⅓	6	...								
Portfires	...	10	1¼	4	½								
Powder ... ... barrels	...	20	25	4	5								
Match, quick ... ... lbs.	...	2	1	1	½								
,, slow ... ... skeins	...	5	1¼	1	¼								
Measures, powder, copper ... sets	1½	1	1½	1	1½								
Electric apparatus with 800 yards insulated wire for firing charges ...	...		2 20	...	...								
Total weight ...	...	...	42 30	...	6 36½								
Road making and Mason's Tools—set.													
Baskets	...	200	4	...	...	...	...	...	...	...	...	...	...
Hammers, sledge	8	10	2	2	16	2	16	2	16	2	16	...	...
,, ,, ...	5	5	25	5	25	4	20	4	20	4	20	...	...
,, Mason's	4	20	2	...	...	...	...	...	...	...	...	...	...
Jumpers, steel	11½	20	5 30	2	23	...	...	...	...	...	...	...	...
Handspikes	5	20	2 20	6	30	4	20	...	...	4	20	...	...
Ropes, drag, 18′, heavy ... pairs	10½	2	21	1	10½	2	21	1	10½	2	21	...	...
Wedges	2	12	24	4	8	4	8	2	4	4	8	...	...
Trowels, 10″, Bricklayer's	⅜	20	7½	...	...	...	...	...	...	...	...	...	...
,, Plasterer's	...	20	7½	...	...	...	...	...	...	...	...	...	...
Plumb bobs and line	...	12	4	...	...	...	...	...	...	...	...	...	...
Lines, chalk, 20 yards, with pins ...	⅛	2	¼	...	...	...	...	...	...	...	...	...	...
Clinometer	¾	2	1½	1	¾	...	...	...	...	...	...	...	...
Crowbars	4	40	4	10	1	4	$\frac{16}{40}$	2	8	4	16	...	...
,, ...	8	60	12	10	2	6	$1\frac{8}{40}$	2	16	6	1 8	...	...
Squares, ground	4	2	8	...	...	...	...	...	...	...	...	...	...
Total weight ...	34 18¼	...	34 28¾	...	5 33¼	...	2 $6\frac{24}{40}$	...	1 34½	...	3 29	...	1 34½

Detail of Field Park Sets, *Continued.*

Description.	Weight of each.	Engineer Field Park.				British Regiment.				Native Regiment.			
		Total.		Advanced Portion.		Total.		Advanced Portion.		Total.		Advanced Portion.	
		No.	Weight.	No.	Weight.	No.	Weight.	No.	Weight.	No.	Weight.	No.	Weight.
Stationery—set.	M. S.		M. S.		M. S.		M. S.		M. S.		M. S.		M. S.
English writing paper, Foolscap quires	..	10	4										
,, Quarto post ,,	...	2	1										
,, Note paper ,,	...	5	$\frac{1}{2}$										
Draft or printing paper, Royal ,,	...	2	2										
Draft or printing paper, Medium, qrs.	...	2	1										
,, ,, Foolscap ,,	...	10	3										
Blotting paper ... ...sheets	...	12	$\frac{1}{2}$										
Envelopes, Foolscap size	...	150	1										
,, Note ,, ...	...	50	$\frac{1}{2}$										
Blank books, English, Flscp., (2 qrs.)	...	2	1	...	10								
Blank books, coarse, Flscp., (3 qrs.)	...	3	1										
Memo. books, (Quarto size)	...	6	1										
Black ink powder ... bundles	...	6											
Red ,, ,, ... ,,	...	2	$\frac{1}{4}$										
Office pencils	...	12											
Colored ,, (red and blue)	...	4	$\frac{1}{4}$										
Red tape (bundles of 7 yards) ...	...	4	$\frac{1}{2}$										
India-rubber ... ... pieces	...	4	$\frac{1}{64}$										
Rulers, round	...	2											
,, flat	...	1	$\frac{1}{2}$										
Goose quills	...	50	$\frac{1}{2}$										
Steel pen nibs	...	100											
Holders	...	6	$\frac{1}{8}$										
Screw top ink glasses	...	3	$\frac{1}{16}$										
Penknives (single)	...	2	$\frac{1}{16}$										
Erasers	...	2	$\frac{1}{16}$										
Paper cutters	...	2	$\frac{1}{16}$										
Scissors (large)	...	1	$\frac{1}{16}$										
,, (small)	...	1	$\frac{1}{16}$										
Wax cloth (piece containing 5 yards)	...	2	4										
Karwa cloth (,, 2 ,,)	...	2	4										

Silk thread (skein 1 tolah each) ...	...	2	$\frac{1}{16}$										
Sealing wax ... ... sticks	...	6	$\frac{1}{4}$										
Paper weights	...	2	$\frac{1}{4}$										
File registers	...	6	1										
Pins, common ... ... packets	...	2	$\frac{1}{16}$										
Gum bottles and brushes	...	2	$\frac{1}{16}$										
Gum ... ... ozs.	...	2	$\frac{1}{16}$										
Total weight ...	...	...	$28\frac{13}{16}$	...	10								
Surveying Instruments, &c.—set.													
Almanacs, Nautical	1	1	1	...	...								
Bannerols with staves	3	6	18	...	...								
Boning rods ... ... sets	$1\frac{1}{4}$	4	5	1	$1\frac{1}{4}$								
Cases, Mathematical	1	2	2	1	1								
,, Sketching	$\frac{1}{4}$	6	$1\frac{1}{2}$	2	$\frac{1}{2}$								
Chains, measuring, with arrows ...	5	4	20	1	5								
Compasses, prismatic	$\frac{1}{2}$	4	2	2	1								
Color boxes	$\frac{1}{8}$	2	$\frac{1}{4}$	1	$\frac{1}{8}$								
Levels, Dumpy	...	2	2	...	...								
,, Abney's	...	2	$\frac{1}{4}$	...	...								
,, staves ... . sets	...	2	8	...	...								
Logarithms, tables of	$\frac{1}{8}$	2	$\frac{1}{4}$	...	...								
Paper, drawing ... ... sheets	...	50	4	12	1								
Perambulators	9	2	18	1wheeled	...								
Pencils, drawing ... dozens	$\frac{1}{16}$	2	$\frac{1}{8}$	...	...								
Pins, drawing	...	50	$\frac{1}{4}$	...	...								
Plane tables	7	2	14	1	7								
Sextant with average bar	...	1	8	...	...								
,, pocket	$\frac{1}{2}$	2	1	1	$\frac{1}{2}$								
Tapes measuring 100 feet	$\frac{3}{4}$	3	$2\frac{1}{4}$	1	$\frac{3}{4}$								
Theodolite with stand	...	1	10	...	...								
Telescopes	$1\frac{1}{4}$	2	$2\frac{1}{2}$	...	...								
Tracing cloth ... ... yards	...	24	2	6	$\frac{1}{2}$								
Scales, Marquois.. ... ... sets	...	1	$\frac{3}{4}$	...	...								
Barometer, Aneroid (small and large)	$\frac{1}{4}$	4	1	2	$\frac{1}{2}$								
Total weight ...	...	...	3 $4\frac{1}{8}$	...	$19\frac{1}{8}$								

Table showing some Stores recommended to be kept in Arsenal, besides those required by the General Table for Engineer Divisional Field Park.

No.	Description.	Remarks.
50	Bamboos, ... large	
100	,, ... medium	
20,000	,, ... small	
10,000	Gabions, ... iron band	
400	Hawsers, ... fathoms, 6 and 4 inch	
1	Pontoon train bridge, ... section	
50	,, trestle ,, ... yards	
100	Portable trestle, with trussed girder, ... ,,	
200 of 5½″ 200 of 1½″	Wire rope, ... fathoms	

Table showing the Establishment of an Engineer Field Park for a Division.

No.	Rank.	Remarks.
1	Superintendent, Captain or Lieutenant, ...	
2	Park Serjeants, ...	
2	Native Non-Com. Officers, Havildars or Naicks, ...	
2	,, ,, ,, Lance Naicks, ...	
7	Total Combatants.	
1	Tindal, ...	
6	Lascars, for general Park duty, ...	
17	,, or 1 additional for every 50 maunds of stores,	
2	Mochies,...	
2	Tent makers, ...	
4	Smiths, ...	
4	Hammermen, ...	
4	Bellows, boys,...	
6	Carpenters, ...	
3	Bhisties,...	
2	Sweepers, ...	
51	Total Non-Combatants.	

Memorandum of Strength, Equipment, and Transport for Divisional Engineer Park.

Corrected to date 30th August, 1879.		Strength.	Horses.	Equipment (mds.)	Transport. Train. Carts.	Bullocks.	Mules.		Hired. Camels.	Mules.	Carts.		Explanatory Detail. Tents. No.	Description.	Weight. M	S
Strength (also Baggage and Transport.) British.	Officers ...	1	2	3¼	...	...	...	...	...	2	...	...	Included in their baggage.			
	Non-Comd. Officers	2	2	2¼	...	...	...	...	...	1		...	1	Pal Lascar,	3	20
Natives.	Havildars, Rank & File	4	...	1¼	...	...	...	...	...	1	...	...	1	Pal Lascar,	3	20
Followers.	Public ...	51	...	12¾	...	...	...	...	3	...	...	...	1 6	Do. Followrs' tents,	3 3	20 0
	Private .	9	...	...	...	...	...	...	...	...	...	...	Quartered by their masters			
Equipment (also Transport).	Baggage total ...			20	...	...	...	...	3	4	...	...	...	...	...	...
	Stores advanced ...			85	...	...	...	...	...	43	...	...	1	Lascar Pal,	3	20
	" reserve ...			728	...	...	...	...	162	40	...	...	1	E.P.	11	0
	Guard			...	...	...	...	...	...	...	...	...	1	Lascar Pal,	3	20
	Office			2	...	...	...	...	...	1	...	...	1	Do.	3	20
	Water			4	...	...	...	...	...	2	...	...	...	...	...	...
	Tents			35	...	...	...	...	7	5	...	...	13	Total ...	35	0
	Grand Totals ...			874	...	...	...	...	172	95	...	...	13		35	0

Arms and Ammunition.

British Non.-Commd. Officers.

Sword and Revolver.

Establishment.

Tulwars.

Followers.

	Description.	No.	Baggage. M.
Public.	Tindal ...	1	¼
	Lascars ..	23	5¾
	Artisans .	22	5½
	Bheesties	3	¾
	Sweepers	2	½
	Total ...	51	12¾
Private.	Officer's servant	1	With their masters.
	Do. horses	4	
	British N.C.O's servants	2	
	Do. horses	2	
	Total ...	9	...
		60	12¾

Explanatory Detail.

Equipment. Equipment as per scale sanctioned for a Division. Of this 25 maunds powder, or at any rate 20 maunds, should be carried by Ordnance. A reduction would also follow on a revised pattern of tent.

Transport. The drivers are not included. They are 1 to 3 camels, and 1 to 3 mules, with 6 per cent., or 1 additional for every 15 mules or every 5 men—In this case 37 muleteers and 57 camelmen. If any carts are used, it would of course modify this estimate.

Proposed Field Park Equipment for the Forces detailed in the margin.

Description of Forces.	Strength.		Equipment.				Transport.					Remarks.
							Train.		Hired.			
	Regiment of Infantry.	Companies of Sappers.	Units of 128 Maunds (Table V.)	Units of 100 Maunds (Table II.)	Units of 64 Maunds (Table III.)	Weight in Maunds.	Light carts with 2 Bullocks.	Mules.	Camels at 5 Maunds.	Carts at 20 Maunds.	Mules.	
Brigade, ... Infantry ...	3	...	2	...	...	256	...	...	12	10	...	Transport being according to description available.
Brigade, ... Sappers ...	...	1	...	1	...	100	6	6	3	1	...	
Total ...	3	1	2	1	...	356	6	6	15	11	...	
Division, ... Infantry ...	7	...	4	...	...	512	...	...	24	20	...	N.B.—The advanced Train for Sappers 64 maunds per Company, and a like amount (64 maunds) per unit of Field Park, should be on light transport.
			...	1	...	100	6	6	3	1	...	
Division, ... Sappers ...	...	2	...	...	1	64	6	6	...	...	...	
Total ...	7	2	4	1	1	676	12	12	27	21	...	
Army Corps Infantry ...	21	...	8	...	...	1024	...	...	48	40	...	
			...	1	...	100	6	6	3	1	...	
Army Corps Sappers ...	...	4	...	...	3	192	18	18	...	...	...	
Total ...	21	4	8	1	3	1316	24	24	51	41	...	
2nd Class Siege Train ...	...	...	...	...	...	1200	...	...	...	60	...	

Memo.—The scale for a Brigade only was sanctioned for each Column moving into Afghanistan.

ADDENDUM.

There are a few numerical errors in the details of these Tables, also a few omissions, which seem worthy of notice.

1.—Uniformity and lightness are most desirable in all parts of this Equipment; these do not exist to a sufficient extent as yet. Field service shovels should weigh $5\frac{1}{8}$ lbs.; pick-axes, 7 lbs. 9 ozs.; spades, $5\frac{3}{4}$ lbs. only.

2.—Bill-hooks are generally of inferior pattern and useless; a description lately made up in the Sapper Park, at Roorkee, is recommended.

3.—The wheelbarrow also should be of the pattern made up at Roorkee; these are superior to any others, their wheels ('Cannell' pattern), are specially good.

4.—The sets given for demolition and road making are not intended as a complete Equipment, *i.e.*, some small stores noted in other places, as push-picks, knives, tarpaulins, &c., might be required.

5.—Norton's field pumps are not included as they are on the Sapper lists, but from the few occasions on which they have been found suitable, it seems likely they may be omitted from those lists, and they might, therefore, be kept in Arsenals in case they were wanted.

6.—Some sheet copper might be useful, amongst other purposes, for work connected with powder stores, for copper shovels, barrow wheels, &c.

7.—The peace establishment for charge of Engineer stores might most suitably be attached to Arsenals.

8.—The subject of detonating fuzes requires careful attention; also some pieces (say 10), of dosootie should be taken to form hose, lighted with port-fires, when fuzes fail.

(*Signed*) F. R. MAUNSELL, MAJOR-GENL., R.E.

PAPER II.

AN ABSTRACT OF

MÜLLER'S HISTORY OF FORTRESS-WARFARE.*

By Captain E. M. Lloyd, R.E.

Colonel Müller is well known by his successive works on the development of the several classes of artillery in Prussia. In the present work he has passed, and to good purpose, beyond the strict domain of his own arm. As a teacher for several years in the War Academy at Berlin, he had occasion to feel the want of any adequate historical account of the reciprocal influence of the changes that have taken place in fortification, and in the means and method of attack. This want he endeavours to supply; and in order to exhibit fully the connection between the two, he goes back to the time of the first introduction of fire-arms, especially as that period furnishes some remarkable analogies to the changes that are now taking place.

The earlier stages, however, are quickly disposed of. Out of the 220 pages of which his sketch—for it is hardly entitled to be called a history—consists, only one-tenth is given to the time before Vauban, and 60 pages bring us down to 1815. Nearly half the book, in fact, is occupied with the work of the last twenty years, since the general adoption of rifled guns.

His mode of treatment is to deal first, in each successive period, with the development of the fortress (the 'Kampfobjekt'), and then with the development of the artillery (the principal 'Kampfmittel'), and to follow this up by a general account of the method of fighting on each side. This way of handling the subject he claims as quite novel; but, so far as the earlier history of fortress-warfare is concerned, it was previously adopted in its main features by the late Emperor

* *Geschichte des Festungskrieges seit allgemeiner Einführung der Feuerwaffen bis zum Jahre* 1880, von H. Müller, Oberstlieutenant und Abtheilungschef im Kriegsministerium. Berlin, 1880.

Napoleon III., in the second volume of his work, *Le Passé et l'Avenir de l'Artillerie*. That, after all, remains the most useful storehouse of information as regards the infancy of the modern art of sieges.

Original or not, the plan is the right one, to interweave the histories of fortification and artillery with that of fortress-warfare; but there is perhaps an unnecessary obtrusion of the skeleton of the work, so to speak, in its execution. The rigorous parcelling out into sections and sub-sections, two or three of which sometimes occur in a single page, breaks the flow of the writing, and leads to a good deal of repetition. There are also several small slips in matters of fact, which make one a little doubtful of the writer's accuracy.*

But exactness, important as it is, is not of so much importance as breadth of view, for a work of this kind. The general relation of the facts is the thing to be brought out, rather than the facts themselves. Colonel Müller's readers will find no reason to complain that they 'cannot see the wood for the trees'; and his grasp of the subject as a whole makes ample amends for any blemishes in detail. The book is good enough to make one hope that he will some day expand it, especially the earlier portions, to the full compass of a history, and provide it with plates, which do so much to relieve and supplement verbal description.

Such histories, it is true, are not much in demand just now. Men of a practical bent are disposed to let 'bygones be bygones,' or at all events to bound their horizon by the Franco-German War. But the chief argument for the study of history in general—that it liberalises the mind and gets rid of prejudice and bias—applies in full measure to the historical study of the art of war. Nothing will help men so much to see things in true perspective, and to measure justly

* The famous siege of Ostend, which lasted from July 5, 1601, till September 20, 1604, is spoken of as lasting twelve months (p. 22). It is by a misprint, of course, that the British loss in the later period of the siege of Burgos is given as 11,222 (p. 98), instead of 1,222; but the misprint is not noticed in the errata. The loss of the allies in the siege of Namur, in 1695, is given as 20,000 (p. 23); whereas, according to General Hamilton (*History of the Grenadier Guards*), it was about 9,000. Vauban is commonly reckoned to have taken part in 47 sieges, of which he directed 40; but he is stated here to have directed 53 (p. 25). According to the best authorities, ricochet batteries were first tried at the siege of Philipsburg, in 1688; but they are here carried back to the siege of Maestricht, fifteen years earlier (p. 29). It is surprising that a writer on the history of fortification should confuse General Prévost de Vernois with Colonel Prévost (p. 87); and so accomplished an artillerist might have been expected to give correctly the composition of the siege train in the British service (p. 187), or at any rate to be aware that smooth-bore mortars have been replaced by rifled howitzers.

the latest novelties of warfare, which are apt to loom so large upon those whose eyes are fixed wholly on the present and the future.

In the absence of any English work upon the same subject, the following outline of Col. Müller's sketch may be useful. A few plates have been added to illustrate early siege operations.

First Period.—From the Introduction of Fire-Arms to the Time of Vauban (1350–1700).

1. (1350–1500.) The walls of towns and castles, when cannon first came into use, were 2 to 3 mètres thick, usually unbacked by earth, and often without ditches. They were high enough to be secure from escalade, and were more or less flanked by towers, placed 36 to 45 m. apart, and intended for hand-weapons. The earliest siege artillery were the bombards, which were at first roughly forged out of iron bars, but, after 1400, were generally cast of bronze. Their length and calibre was gradually increased, in order to extend the range of the stone shot used with them, which attained to about 2,000 m. There were also small-bore pieces: falconets, cannon, and culverins. About 1450, mortars were introduced, to project stone shot of very large calibre, and fireballs; but, owing to their small effect, they dropped out of use, until the adoption of iron shells, in the seventeenth century, gave them a new value. Both for bombards and cannon, direct frontal fire with full charges was at first exclusively used, to cut down the walls at the top, and drive the defenders from the battlements. The introduction of cast-iron shot in France, in 1471, led to an increase in the calibres of the cannon, and a decrease in those of the bombards. Regular breaching took the place of mere demolition fire; and Charles VIII., in 1498, took many Italian towns with surprising rapidity by a pure artillery attack. The defenders were driven from their loopholes by the lighter pieces; then the heavy guns were brought close up, a span of wall or a gate was laid open, and the assault delivered. Against strong walls, however, this method often failed, as at Ravenna in 1512, &c. (*see Contributions to the History of Breaching by Mines and Artillery*, vols. 55 *et seq.* of the *Archiv für die Artillerie-und Ingenieur Corps*). As guns came also to be employed in the defence, it was found necessary to protect the siege artillery by breastworks revetted with casks,* and to abandon the use of the older engines of attack, which survived for

* Or more probably constructed of them, just as batteries were afterwards constructed wholly of gabions, which were sometimes as much as 10 feet high and 7 feet in diameter. *Pl. I.* shows batteries of this character. It is taken from a work of

more than a century after the first introduction of fire-arms. Movable towers, or belfries, were last used by the Turks in 1453, at the siege of Constantinople, but were soon destroyed by the guns of the besieged.

In the middle of the fifteenth century, trenches began to be made use of as siege approaches. Before Honfleur,* in 1450, they were pushed forward in zigzags from a distance of 250 to 300 m. In the latter half of the century, something like a system of attack had been developed, owing chiefly to the Turks, who, in the siege of Constantinople and in their wars with the Venetians, introduced many novelties, which were afterwards adopted in Western Europe.

Men early endeavoured to employ cannon in defence as well as in attack, but the walls and towers were ill-suited to them. Earthen ramparts were made for them at the back of the walls, if they were strong enough and not too high; or, if the wall was weak, the rampart was retired to some distance from it. The towers were lowered and solidly filled up, so that guns could be mounted on them. In the case of new works the changes went further. The walls were made strong enough to support ramparts, and while their height (9 to 11 m.) was maintained, they were partly sunk below the ground. The towers were enlarged into 'roundels,' which soon developed into angular bastions, as that form was found more convenient for fire in definite directions (and was also less easily breached). Their distance apart was extended to 375 to 450 m., but in the interval between two bastions there projected a small work called a *moineau* (or platform) to cover the gateway. The earliest bastions—those designed by Martini at the end of the fifteenth century—had short flanks, long faces, and blunt salients; the faces serving merely to cover the flanks, which alone were habitually armed with artillery.

II. (1500–1700.) The things chiefly required in fortification at the beginning of this period were:

the middle of the sixteenth century, where it is given to illustrate the defects of square forts, and how the besieger may attack them. If the salient is breached, says the writer, there is good cover for the enemy there, and in any case his pioneers advancing upon the bulwark are exposed to little fire. He can make batteries to choke the guns in the flanks, and he can easily ruinate the shoulder, and so uncover the flank behind it. Or, if he wishes to breach the curtain, he can enfilade it by a mount, so that, 'when occasion shall serve, that the men should appear for the defence of the breach or walls of the curtain, they shall find themselves subjected by the same mount in such sort as they shall not be able to abide thereat, when the assault should be presented.' (*See* Appendix E of the *Woolwich Text-book of Fortification*—'The Key of the Treasury.')

* Or rather Harfleur, on the other side of the Seine. After Harfleur was taken, Honfleur surrendered without standing a siege.

(1) Better arrangements for artillery defence in general.
(2) Better cover for the walls against direct fire.
(3) Good flank defence by artillery.
(4) Protection of the entrances, both from access and from fire.
Of these, the two first chiefly affected the profile, and the two last the trace. To meet these requirements, bastioned fronts were developed gradually and with many variations; each country taking more or less its own line, but the Italians leading the way.

The earlier Italian engineers, of whom San Micheli and Tartaglia are representatives, made their fronts very long and their bastions small. The salients of the bastions were usually blunt, the faces unflanked, and unable to cross fire upon the ground in front of the curtain. The flanks, in two or three tiers, were perpendicular to the curtain, and were partially casemated and protected by orillons. In the later Italian manner, as described by Marchi in 1599, the bastions were better flanked and gave a better cross-fire. Tenaillons and counter-guards were placed in front of them, and a *revellino* in front of the curtain.

During the sixteenth century Italian engineers were in request all over Europe, and while Paciotto was building the citadel of Antwerp (1574), Chiamarella was building the citadel of Spandau. Germany produced two remarkable engineers, Dürer and Speckle, but they founded no schools. In France the Italian principles were followed out, and in the hands of Pagan (1645) modified to the advantage of the close defence. In Holland, during the war of independence, a cheap mode of fortifying was developed, with low earthworks and wide wet ditches, which gained a high reputation and was afterwards adopted elsewhere. The great Elector brought Dutch engineers to Prussia, and set them to fortify Colberg and Minden in 1650.

A review of the development of bastioned fortification in the sixteenth and early part of the seventeenth centuries shows that the bastions, being made larger and closer, became more capable of frontal action, while their flanking fire was studiously improved and secured. The walls were only partially hidden, because so much stress was laid upon high escarps; but various kinds of construction were adopted to make them more difficult to breach. The covered way was not fully matured, and its communications, both to the front and rear, were imperfect.

Meanwhile there was considerable progress both in guns and gunnery. By the middle of the sixteenth century the use of iron shot had become almost universal, and the calibres of guns were further reduced, and more definitely fixed. Double cannon, 42-pounders, were the heaviest pieces in France; 48-pounders in Germany. Direct fire at 450 to 600 m. was chiefly used for dismounting and breaching. The latter was usually unsystematic, from above downwards; though Frundsberg (1566) gave several rules for it, recommending that a horizontal cut should be first made, 2 m. above the foot of the wall. Enfilade fire was employed before the middle of the sixteenth century (*Pl. I.*), and traverses to guard against it were designed by Marchi and Cataneo.

At the beginning of the seventeenth century, hand-grenades, and, shortly afterwards, shells fired from mortars, came into general use. About 12,000 hand-grenades were thrown at the siege of Maestricht (1673), and nearly 24,000 at Stettin (1678). The calibres of the mortars were nearly those of the present day—13-inch, 10-inch, and 8-inch; and in 1674, at Grave, Coehorn introduced the small mortars named after him. In France there were also *pierriers*. Incendiary projectiles were fired from mortars, and case from guns. At Grave, both sides used case largely.

Down to the time of Vauban, the bulk of the siege artillery was commonly placed in one large battery, called in France *batterie royale*, and in Germany *general-batterie*. Against places ill-provided with outworks this battery was made opposite the curtain, 450 to 600 m. from it. It served, if possible, for breaching as well as dismounting, so as to save the labour of shifting the guns forward, and to allow the more advanced trenches to be made narrow. When ravelins became common, and the faces of the bastions took a more active part in the defence, the attack was directed chiefly upon them. As their flanks were carefully hidden, batteries had to be made on the glacis at the salients to silence them, and often others also to make breaches. Even where breaches were made from a distance, it was sometimes found, as at Menin (1700) and Lille (1708), that it was impossible to make use of them. The approaches had to be carried forward to the glacis, and batteries made there, after all. The massing of guns in one general counter-battery was opposed by Vauban; but it found an advocate in Coehorn, and was practised on a great scale by the Turks, who had 74 guns in one battery at Famagosta. To give some other instances: there were batteries of 44 guns before Mayence, in 1674, and before Lille in 1704, and there was a battery of 60 guns before Turin in 1706.

Enfilade batteries were more rarely used. Like the counter-batteries, they were mostly raised above the surface of the ground; sometimes, especially by the Turks, they were placed upon high cavaliers, because, with full charges, enfilade fire from a lower level was ineffectual. A battery before Maestricht, in 1579, was 8 m. high, and the cavalier battery for 6 guns, built by the Spaniards during the siege of Ostend, occupied eight months in construction.

The increased effect of improved guns, and the great results obtained by mortar fire against works as yet unprovided with bomb-proof cover, and against buildings, together with the want of skill at that time in the management of the approaches, all tended to develop the artillery-attack, and caused it to be relied upon more and more. This was much less the case with France, in Vauban's day, than with the allies opposed to her; and Coehorn was the chief representative of this tendency. At Liége, in 1702, the siege train consisted of 480 pieces (including 300 small mortars), and at Bonn, in 1704, it consisted of 646 pieces (including 500 small mortars). With the artillery-attack assaults were often combined, which in most cases cost many men and proved unsuccessful. The attempt to storm the covered way cost 5,000 men at Mayence (1689), and 4,600 at Lille (1708). Bombardment of the town buildings became also a recognised mode of attack. Stettin, in 1676, had 30,000 shells thrown into it, some of them weighing 4 cwt.; and Stralsund surrendered, in 1678, after a five-days' bombardment from 52 mortars.

During these two centuries several steps were made in the conduct and execution of the trenches. Returns were made, to flank the approaches, *e.g.* by Montluc at Thionville (1558). Traversed saps were employed in the second half of the sixteenth century;* and in 1578, for the first time in Western Europe, the Turkish earth sap was made use of, before Deventer. As outworks giving a grazing fire were added to fortresses, it was found necessary to open the trenches at

* In the earliest traversed saps the traverses seem to have been formed overhead, by blinding portions of a direct approach. A trench was made in this way by the engineer Campi at the siege of Haarlem (1573), and Mendoza speaks of it as a novelty. At intervals there were wooden uprights, carrying joists on which sand-bags were laid, the joists forming a kind of bridge. *Chandeliers*—frames consisting of a ground sill, with two uprights, between which fascines could be piled—became recognised siege stores in the seventeenth century, being used both for blinding trenches and for forming breastworks where excavation was impossible. The siege of Bois-le-Duc (1629) affords an early instance of the ordinary traversed sap (*see Pl. II.*). On the N.E. side the attack, directed by Count Ernest of Nassau, was hindered by the swampy ground. At length he 'was advised by his engineer, Matthias Van Voord, to make a great gallery directly upon the city . . . which should be made in this manner. The plain thereof should be a foot high above water, and 12 foot broad between the walls thereof on both sides, which walls should be cannon-proof. And at every 8 or 10-foot length a traverse to be made also cannon-proof. . . . To this end the two batteries (D and E) were put forth to be made, each of them for 8 pieces of ordnance, the wings or hinder part thereof closing together,

greater distances. The besieged, unable to make any impression on them by fire, had to resort to sorties to hinder their progress, and these were facilitated by the general adoption of the covered way. Hence, with enterprising garrisons, 'skirmishing' in front of the place became a chief feature in the defence. Cavalry took part in it, and the besiegers found it necessary to have cavalry of their own near at hand, behind epaulments. Sometimes, as at Grave, foot soldiers were taken out mounted behind the horsemen, and the former dismounted and attacked the advanced siege works while the horsemen pushed on to hold reinforcements in check. To guard their trenches and batteries against such attacks, besiegers made redoubts at the angles of their zigzags; and as fire-arms gradually superseded pikes, it was found advisable (*e.g.* by the Swedes in the Thirty Years' war) to throw out 'lines'—the rudiments of parallels — which afforded better firing positions than the redoubts.

The method of attack elaborated in the Dutch war of independence, and known as 'the method of the Princes of Orange,' was a combination of the three elements—trenches, batteries, and redoubts. It began with the construction of continuous lines of circumvallation and contravallation, with redoubts or forts in front of them, armed with artillery. The trenches started at 230 to 330 m. from the place; the redoubts, or *corps de garde*, at their angles, not only defended them, but also the batteries, which lay close by.* The whole group of works upon any one capital was termed 'an attack.'

The artillery of the fortress at first confined itself to the defence

and having on the sides *corps-de-garde* for the safety of the batteries. . . . And by reason that the place where this great gallery was to be made was altogether a morass, which was overflowed with water at some places a man's height, we were fain to fill the way, as we worked forward, with brush and earth, which was brought thither from afar off in carts. And for the more security of this gallery there were made the batteries F and G.' (Prempart, *Siege of the Busse*, 1630.)

* *Fig.* 1, *Pl. III.*, shows the disposition recommended by Marollois (*Ars Muniendi*, 1614). The working party, from 200 to 400 men, is extended along the line of the intended trench by 'the mathematician who directs the works,' the men being 3 or 4 feet apart. The guard lie down, taking care to hide their burning matches from the enemy, and throwing out scouts towards the place. If a sortie is made, and they find themselves unable to hold their ground, both guards and workmen must fall back upon the *corps-de-garde*. The trench should be made 3 feet deep and 6 feet wide, and at the end of the line there should be a redoubt (or *corps-de-garde*) of about 20 yards side, which must be ready by daybreak to receive the scouts and to resist the enemy. Freitag, another Dutch engineer of the same time, places the redoubts, not in the line of the approach, but at the end of short lateral trenches on either flank of it (*Fig.* 2, *Pl. III.*). The Spaniards seemed to have trusted usually to returns, like those of Montluc, which afforded a flanking fire (*Figs.* 3 and 4).

of the curtain from well-hidden flanks. But the counter-batteries, which after a time besiegers began to make on the glacis at the salients of the bastions, proved able to search out and overpower these flanks. The besieged then tried to arrest the progress of the besiegers at an earlier stage, by engaging their general-battery, at first from the curtain, but afterwards from the faces of the bastions, as these were found to give a more convergent and effectual fire. Gradually the artillery defence centred more and more in the bastions, which grew larger and more salient. They enveloped and often mastered the general-battery of the besiegers; and so long as they were unsubdued, the infantry and cavalry of the garrison were free to take the offensive against the narrow front of the attack. Mortar fire, it is true, told chiefly in favour of the besiegers, especially the fire of the heavier mortars. But, in spite of this, the defence was on the whole decidedly superior to the attack: active in the earlier, obstinate in the later stages. Its activity was furthered by the fact that sieges were not as yet reduced to mere engineer operations of a fixed pattern, and that commandants were mostly experienced soldiers accustomed to handle troops in every way. Consequently, besides the prolonged sieges of the Dutch war, we find the siege of Candia lasting 28 months (1667–9), Grave four months (1679), Mayence three months (1689), &c.

Second Period.—From the time of Vauban to the end of the Napoleonic Wars (1700–1815).

I. (1700–1740.) The experience acquired in the Dutch war of independence, and in the Turkish sieges (especially the siege of Candia), was greatly extended in the long wars of Louis XIV. against Holland and Germany. In these wars the French were usually the besiegers, and Vauban in particular, in the many sieges he directed, had abundant opportunity for noting the improvements required, alike in fortification and in the art of attack.

As regards fortification, three men took the lead in altering the practice of their time:—Vauban (1633–1707), Coehorn (1641–1704), and Rimpler (1640–1683). All alike, though with widely different results, set aside the doctrines then in vogue, and worked unfettered upon the lines which circumstances and their experience marked out for them. The chief defects to be corrected were:

(1) Faulty trace, especially as regards the use of artillery in the distant defence.

(2) Insufficient cover for the masonry.

(3) Want of secure shelter against the increasing vertical fire.

(4) Want of retrenchments and keeps for interior defence. Vauban, in his later system, tried to remedy these with only partial success. In the attack of Luxemburg, in 1684, he had been held in check for ten days by the pentagonal towers with two tiers of gun-casemates built by Louvigny (1673–83), and from these he borrowed his tower bastions.* The casemates of these tower bastions were shown by trials, not strictly fair, at Landau in 1704, to be inconvenient for artillery service; and the French entirely abandoned gun-casemates, their aversion to which has subsisted until quite lately.

Coehorn laid great stress on a step-by-step defence by means of outworks and retrenchments; and by his skilful combination of wet and dry ditches, and his keeps (especially those of the covered way), he gave great facilities for an active defence. He covered his masonry well; and with his double flanks and orillon towers he obtained a powerful flank fire.

Rimpler's experience was drawn chiefly from the defence of fortresses, especially that of Candia, in which he had taken part. This led him to set much store by sorties and retrenchments. The latter he multiplied to excess. To assist sorties he provided a dry outer ditch, and a double glacis with casemated keeps in the covered way. He recommended that, instead of spending money on high escarps, numerous casemates should be built, because 'high and costly walls are only calculated to guard against assault, and afford no other advantage, except to the besieger, who can very soon bring them down.'

As regards siege operations, Vauban had been early struck with the disconnected way in which the saps were pushed on, the insufficient extension of them in the last stages of the siege, and the want of skill in the disposition and use of the artillery. In 1669 he wrote his first treatise on sieges; † and in 1673, before Maestricht, he departed from

* This seems to be mere conjecture. The towers at Luxemburg were advanced works on the glacis, not part of the enceinte. Vauban thought well of them, and built others like them; but he himself says that the tower bastions were suggested to him by the difficulties of the site of Belfort.

† In this treatise, after pointing out the mistakes commonly made in sieges at that time, he illustrated his remarks by contrasting the attack which he had himself directed against Lille, two years before, with an imaginary attack upon the same front (*see Pl. IV.*). He blames the artillerymen for placing their batteries too far off, and on what was practically one straight line, instead of studying to get some convergence of fire. He owns that, owing to the want of workmen, he pushed forward his sap on the left with very insufficient support. The same error was committed in forming the lodgment on the counterscarp. No precautions were taken against sorties on the left, and no batteries made to oppose the outworks on that side. The assault

the common practice, and introduced parallels—previously employed by the Swedes and by the Turks*—to connect the approaches, and to receive the guards. He dispersed his batteries to some extent; and, for the first time, he formed a 'crowning' on the glacis. By these means he brought one of the best fortresses in Holland to surrender in 10 days, at a cost of only one-tenth of the usual number of men. His success gave him henceforward more freedom of action; but there were many difficulties in the application of parallels, especially the disorder attending the extension of the workmen, and it was not till the siege of Ath, in 1697, that these difficulties were fully overcome, and the parallels properly executed. At Ath, also, ricochet fire first showed its value, in spite of the distaste for it felt by the artillery. It had been previously tried, but without marked success. At Ath, 5 batteries armed with 30 guns (12-pounders and 8-pounders) in the second parallel, about 260 m. from the place, dismounted 83 guns in a few days.†

In the *Traité des sièges et de l'attaque des places*, written by Vauban a few years afterwards, a precise system of attack was laid down, which, based as it was on his vast experience, has served as a

on the ravelin, though it proved successful, was premature and hazardous, for there was no breach in the work, no gallery of descent into its ditch, and no lodgment on its counterscarp. And yet this attack, he says, was a very favourable example, and met with much approbation. Hence he concludes that, 'when we succeed, it is rather owing to the weakness of the enemy than to our own merit.'

* The author does not mention the instances in which they were employed by the Swedes. They were employed by the Turks in a quite unsystematic, but in a most wholesale manner, during the siege of Candia (1667–9), and it has been supposed that Vauban borrowed them from the Turks. But there is no sufficient proof of this, and it is evident that the idea of parallels was already afloat in Western Europe. It is developed in Vauban's treatise of 1669, and it is to be found also in a work published the year before (*Livre de toutes sortes de Fortifications*, by the Sieur D'Aurignac). The writer proposes a plan of attack which he says he had successfully practised at Bellegarde. The approaches start from one grand place of arms, 12 feet wide (*see Fig. 5, Pl. III.*), and at every 50 yards they are crossed by other places of arms, each intended for half a battalion. At 18 or 20 paces from the salient of the counterscarp of the ravelin, they are connected by 'trenches parallel to the place,' 6 feet wide, under cover of the musketry fire from which the three lodgments on the counterscarp can be made simultaneously.

† Batteries I. to V. of those shown on *Plate V.* The defence was so passive that Vauban did not think it worth while to make a third parallel. The besieged had made an inundation on the left flank of the attack with the waters of the upper Dender, which was maintained by a sluice opposite the Burgundy bastion. They hoped, with the full head of water which this furnished them, to scour the main ditch when the besiegers were crossing it; but before that time the sluice was breached by a battery of 3 mortars (No. VII.), which threw shells of 5 cwt.

pattern until quite lately. His siege train consisted of 130 guns, 80 mortars, and 80 *pierriers*. The investment was secured by continuous lines, with a ditch 15 to 18 feet wide, and 6 to 7½ feet deep. The first parallel was about 575 m., the second, 225 to 275 m., and the third, 30 to 45 m. from the place. The 'crowning' furnished a final infantry position on the crest of the glacis, and also received the breaching and counter-batteries. He preferred to use artillery for breaching, rather than mines, as had formerly been customary, because, 'with artillery,' he says, 'one can breach when, where, and how one pleases.' The infantry, in Vauban's scheme, took no active part in the attack, but merely acted as guards, except in the special cases where it might be necessary to storm the covered way or the breaches. The batteries for silencing the fortress were, if possible, to be so placed as to enfilade and ricochet one face while directly engaging another; by preference in the second parallel, but at all events not behind the first parallel. The main principles of Vauban's system of attack were:—To surprise and envelop the enemy as much as possible, always to be prepared against sorties, and to obtain an artillery superiority by dispersion and convergence rather than by number of pieces.

In a second treatise he dealt with the subject of defence. Sorties, in face of his own precautions against them, he had little faith in. He declared, indeed: 'I have never seen a siege in which sorties have delayed the progress of the attack by so much as half a day.' But he recommended that they should be tried on the first nights of breaking ground, and whenever special circumstances or the remissness of the enemy gave opportunity for them. He also advised a sortie in force against the crowning of the glacis, and frequent small sorties during the defence of the covered way. To hinder the execution of the first parallel by musketry fire, he would have sharpshooters posted at night 100 to 200 m. in front of the covered way. But in the main he would use his infantry defensively, to hold the ramparts and the covered way against assault. The saying is ascribed to him: 'Covered way lost, all lost.'

As regards the artillery defence, he looked chiefly to mortars. 'The fury of the attack,' he says, 'is beyond measure increased by the great number of guns and the extensive use of shells; therefore, numerous mortars must be employed in the fortresses too.' As soon as the fronts to be attacked were known, as many guns as possible should be mounted upon them, but a direct engagement with the besiegers' batteries should be avoided, and the pieces transferred to the neighbouring fronts which were not enveloped. This direction was acted upon with much success by Vallière, who commanded the artillery, in the defence of Aire, in 1710. He shifted his guns from place to place, cutting new embrasures where the enemy least looked for them. He had also invented a heightened carriage, which allowed of fire over the parapet without cutting embrasures.

The engineer operations in the defence consisted chiefly in mining and in making counter-approaches. The latter were used at Grave (1674), Philipsburg (1676), and Mayence (1689).

Reviewing this period, we see that the chief part in the attack, which had before lain with the batteries, was shifted by Vauban to the systematic and steadily advancing sap with its strong infantry guard. The active infantry defence, hitherto superior, was broken by this infantry attack, strong both for offence and defence; while the artillery attack, widely distributed and enveloping, gave frontal, enfilading, and high-angle fire against the bastions, and quickly annihilated the artillery distant defence. Hence the superiority was transferred in all respects to the attack. The preponderance was especially marked in the earlier stages: in the later stages, particularly after the attack had reached the covered way, it was itself taken more in flank, while the besiegers' guns had partially to cease firing lest they should injure the siege works. The close defence, therefore, still retained much value.

Instances like the capture of Bonn in twelve days (1703), Landau in five days (1705),* Ath in eleven days (1706), showed what skilful besiegers could do with a feeble defence; but there were other instances, such as that of Tournay (1709), held for 57 days against Marlborough and Prince Eugene, which showed that a stout and prolonged defence was still possible.

II. (1740–1815.) The predominance in military matters which the French had attained at the end of the seventeenth century caused other nations to follow their lead, and made bastioned fortification, for about 100 years, the prevailing, or, as we may say, the historical, type throughout Europe. Yet this did not prevent abundant variations of detail, and it is reckoned that in this century there were upwards of 180 revisions of Vauban's trace.

Cormontaingne, by enlarging the bastions and ravelins, brought more fire to bear upon the ground in front, but at the same time increased the length of line which was exposed to envelopment. He rejected those germs of a good retrenchment which were to be found in Vauban's later system. He covered all masonry from direct fire from

* This is a mistake. Landau was not besieged in 1705; it was besieged in each of the three preceding years, but the defence in all cases extended much beyond five days.

a distance, but at the sacrifice of strong profiles. The advanced lunettes at the foot of the glacis, which were adopted by the school of Mézières, did something to facilitate offensive action upon the ground outside. This was also furthered by the detached ravelins, and the well-organised covered ways, proposed by Bousmard and Chasseloup; and it was a main object with Carnot, who suggested a counter-sloping glacis for the sake of it. The two former engineers made some use of casemates for the flank defence of their ditches, while Carnot adopted them largely for high-angle fire.

Wallrawe, a Dutch engineer, who entered the Prussian service in 1715, and Frederic the Great, who, after the death of Wallrawe, took the direction of fortification works into his own hands, departed from the bastioned trace, and adopted in general a tenaille trace, with reverse flank defence from counterscarp galleries. Schweidnitz was provided with an enceinte of polygonal trace flanked by caponiers, and also with five detached forts, and other advanced casemated works, which favoured an active defence. Graudenz, which fell to Prussia in 1772, was fortified after Frederic's own designs. In all the works casemates were largely used, both for shelter and defence; the ditches were narrow and deep, so that the walls were well hidden and difficult to breach.

In Austria, as in Prussia, fortification, to some extent, broke loose from the French school. General Harsch, in 1763, pointed out the faults of Cormontaingne's system, and in fortifying Arad he used polygonal fronts with detached bastions in the middle of them.

The first Frenchman to raise his voice against the dominant system was Montalembert, who was the more unfettered from the fact that he was not himself an engineer officer. He took as his main principle that the defender must secure a superiority in number, calibre, and protection of pieces at every stage of the siege; and this demanded the abandonment of the bastioned trace, and the general adoption of gun-casemates, tier above tier. The polygonal trace, which he developed to meet these requirements, afforded long fronts, capable of mounting an immense number of guns, and which were difficult to envelop and difficult to overpower by frontal fire.

The material of artillery was reorganised during this period, by Gribeauval in France, and by Frederic the Great in Prussia. Great attention was paid to gunnery, and the ballistic problems bearing upon it were investigated by Robins, Euler, Hutton, &c. Ricochet fire, though reckoned by Cormontaingne the best kind of fire, made its way slowly in Germany. The first experiments with it in Prussia took place at Berlin in 1749. The adoption of traverses to guard against it raised many questions as to its use: what point should be aimed at, what elevation given, whether the bounds should be short or high, or long and flat, &c. Opinions were very divided on these points, and Du Puget (1771) distinguished high ricochet and flat ricochet as separate kinds of fire. The increased use of howitzers gave the former kind the preference in most cases. The ranges recommended varied from 570 m. to 750 m., but these were often greatly exceeded in practice, and the batteries were placed too far off for accuracy of fire with low charges. Hence many writers, such as Morla, Hoyer, and Tempelhoff, thought little of ricochet; and Scharnhorst considered it effective only at short ranges. Its value, when properly used, was, however, sufficiently shown by the numerous attempts made to improve fortification so as to obviate its effects. For breaching, the best rules were given by Morla, in 1796. He prescribed a horizontal cut, 1 or 2 m. above the base of the wall, and then two vertical cuts. Oblique was preferred to perpendicular fire, but, according to Cormontaingne, the horizontal angle should not be less than 45°, nor the range exceed 230 m.

As regards the general course of siege operations, both engineer and artillery, there was very little deviation from the rules laid down by Vauban. His disposition of the trenches, improved in some minor details by Cormontaingne and his successors, formed a definite scheme of attack, which soon came to be regarded as perfect and unfailing. Lefebvre (1757) proposed to modify the trace of the parallels: to make the first and third re-entering, and the second straight, the ends of the second parallel resting upon the two branches of the first, while its centre was the starting-point of the two branches of the third. By this combination of parallel and approach in one he hoped to save time and labour, but his plan found no favour. In mining, Bélidor, by his globes of compression, broke down the previous superiority of countermines, and the art of underground warfare was further developed by the siege of Schweidnitz, and by the work of Lefebvre based upon that siege.

After the war in Flanders (1744–8) the ricochet batteries were placed in the first parallel, sometimes with ranges of 1,000 m. or more. The artillery attack began with them and with the heavy mortar batteries; it was reinforced by the frontal fire of the counter-batteries in the second parallel, at ranges of 300 to 450 m., and was afterwards supported by the fire of light mortars and *pierriers* in, or in advance of, the second parallel. In the crowning there were counter-batteries of 12-pounders, and breaching batteries of 24-pounders, unless, as at Tournay and Valenciennes in 1793, the breaching could be done from a distance. The number of pieces in each battery varied from four to ten. Vauban had disapproved of the bombardment of towns, and in this he was followed by the whole French school. D'Arçon and Carnot spoke of it as ineffectual; Bousmard, as inhuman. It was tried without success by Frederic the Great, at Prague, in 1757; by the allies against Thionville, Lille, and Valenciennes, in 1792–3; and against Wittenberg in 1813. But it led to the surrender of Longwy and Verdun to the allies in 1792, and of Breda, Ypres, and Maestricht to the French in 1793-4.

The systematic attack was often abridged or accelerated under special circumstances. This was the case especially with the British sieges in Spain, owing to the deficient engineer equipment of the besiegers, and the old-fashioned places with which they had to deal. The breaches were made at long distances, but with great expenditure of ammunition. They were often difficult to reach, and difficult to mount, and it was impossible to reconnoitre them; while the defenders were able to prepare obstacles on them, and to form up behind them in readiness for the stormers. Hence the loss of 3,000 men at the breaches at Badajos, and of 4,000* men in the assaults at San Sebastian. Nevertheless, the British attacks on Ciudad Rodrigo and Badajos succeeded in half the time taken by the more regular attacks of the French upon those places two years before. The Prussians, in 1813-15, successfully accelerated their attacks by opening the first parallel as close to the place as possible, and making the batteries simultaneously with it.

The superiority of the attack over the defence was looked upon at this time as an unquestionable fact, which it was vain to struggle against. The part of the defence was merely to delay the advance of the besieger, so far as that could be done with small expenditure, and to reserve the main stock of material for the last stage of the siege. Vauban's unfavourable opinion of sorties was generally accepted, and even pushed further (*e.g.* by Cormontaingne and Bousmard). Carnot was the first Frenchman to take the opposite view.

As to the use of artillery in the defence, the prevailing opinions (as expressed by Morla in his handbook of artillery, in 1796) were generally as follows:

(*a*) Before the attack begins, the greatest possible number of guns should be mounted on the front attacked, and their fire kept up night and day.

(*b*) The main thing is to delay the enemy; therefore, a heavy fire is maintained till their batteries are finished. When that has been

* 2,500, according to Sir J. Jones, viz., 500 killed and wounded in the assault of July 25, and 2,000 in the assault of August 31.

accomplished, a combat with them should not be attempted, but the heavy guns should be transferred to the adjoining fronts.

(*c*) With the light guns one should try to manœuvre on the ramparts, and to make use of every favourable opportunity to open upon some one point with an overwhelming fire. At night the fire should be increased. Heavy shells should be used; and when the enemy comes close, there should also be high angle fire from small mortars.

(*d*) In the last stage, guns and ammunition should be expended, so that nothing may remain to be surrendered.

(*e*) Fire through embrasures is to be avoided.

Montalembert was strongly opposed to these principles of defence, and was for engaging and overpowering the besiegers' batteries from the outset. Virgin also (in 1781) advocated a vigorous use of artillery, especially of mortars. But Cormontaingne, Fourcroy, and many others regarded artillery as playing a secondary part in the defence; and Cormontaingne accordingly reduced the armament for a hexagon to 68 pieces. 'One attacks fortresses with artillery, one defends them with musketry,' is a saying attributed to General Riboisiére. Even Carnot, strongly as he recommended high angle fire, considered it a mistake to expend much ammunition in the earlier periods of the siege.

The admitted superiority of the attack, and the inability of the defence to make head against it, made the surrender of a fortress a mere question of time, and a question which engineers soon came to regard as admitting of easy calculation. Vauban, in order to arrive at data for the provisioning of fortresses, had determined the average duration of the several stages of the siege of a regular hexagon, according to his experience, and had so set the example of paper attacks. These were developed by Cormontaingne and Fourcroy, and converted into an 'analysis of fortresses,' a mode of measuring their relative strength. According to this gauge, a place fortified after Vauban's first system would hold out 19 days, after his third system 26 days, after Cormontaingne's system 32 days, and after Coehorn's system 21 days. These numbers were to be regarded as maxima which no energy or intelligence on the part of the garrison could extend.* If, as

* The authors of this much-abused method say distinctly that they exclude from their hypothesis the effect of sorties, mines, counter-approaches, and improvised retrenchments, and assume the garrison merely to hold their ground and keep up their fire with ordinary tenacity. They point out that, if they were estimating the munitions required for a fortress, all the above resources of the defence would have to be taken into account, and the probable duration of the siege might be doubled. (*See* Cormontaingne, *Memorial pour la Fortification permanente*, p. 101, and the *Mémoires sur la Fortification perpendiculaire*, by Fourcroy and others, p. 22.)

military history proved, they were often exceeded, this was due to the blunders of besiegers.

The effect of the general acceptance of this mode of measurement was to reduce the defence, as Carnot said, to the 'art of honourably surrendering fortresses according to certain agreed formalities.' Its fruits, according to Reiche (1812), were—'A disastrous feebleness in the defence, a depreciation and mistrust of fortification, embarrassment and perplexity for weak minds, a screen for neglected duties, and a pitiful way of judging of the defences that took place.' According to Bousmard (1797), 'nine places out of ten surrender without waiting for an assault.' Carnot's work, *De la défense des places fortes*, was written by Napoleon's wish to oppose this sort of teaching; but it had little effect. The inferiority of the defence sprang from faults in fortification, and it was only by curing them that it could be removed.

Cormontaingne and his successors, though they made some small improvements in bastioned fortification, were unable to get rid of its main defects—its unsuitableness for a good artillery defence, and for the active use of infantry in sorties. At the same time they cast it into so rigid a form that it was incapable of further development, and they set their faces against all radical change.

Vauban's eminence had thrown the direction of sieges into the hands of the engineers. With them the conduct of the sap became the principal thing, to be escorted by infantry and supported by artillery. The number of guns in the siege train had been considerably reduced by Vauban, owing to his more skilful and methodical use of them; and Cormontaingne further diminished this number, and more narrowly restricted their use. The same course was followed as regards the defence, which, both in respect of artillery and infantry, tended to become purely passive, owing to the little scope which the mode of fortification afforded. A good defence became rarer and rarer; commandants less capable, and more ignorant of fortress warfare. 'For nearly a century,' wrote Bousmard, 'the conduct of the attack and of the defence has been left to the engineers alone; and the study of such operations has been neglected by all other soldiers; so that now generals, commandants, and garrison officers find themselves almost wholly ignorant of the first and most essential elements of the art of fortification. The attack of fortresses was left entirely to Vauban after his first successes: others did not concern themselves any more about it, and regarded it as too difficult; and so began this mischief.' Frederic the Great declared: 'En général, ni les fortifications, ni le nombre des soldats defendent une ville, mais tout dépend de la tête plus ou moins forte de celui qui y commande'; yet most of the Prussian commandants in 1806–7 were old men, physically infirm, and without the slightest acquaintance with the first conditions of fortress-warfare, who afforded disastrous confirmation of the truth of his words. Here and there, men like Gneisenau at Colberg, and Kalkreuth at Dantzig, showed how much might be done even with indifferent fortresses; but these men were not engineers, and probably they had the good fortune to be utterly ignorant of the French system of defence.*

In the war in Flanders (1744–8), Ath, Antwerp, Charleroi, and Namur were taken within a week; Brussels and Lille within a fortnight. But Berg-op-Zoom (1747) held out for nine weeks, owing chiefly to the delays of mine warfare. This in itself occupied seven weeks at Schweidnitz (1762), during which time the besiegers gained only 50 m. of ground.

Throughout the eighteenth century the French maintained their position as the most skilful and experienced besiegers. The Revolution broke up the Corps of Engineers, and for a time artillery attacks had to be adopted. But later, especially in Spain, the French engineers revived their former fame, both in their attacks and defences (*e.g.*, Tortosa, Tarragona, and San Sebastian).

Third Period.—From 1815 to the General Introduction of Rifled Weapons in 1860.

After the end of the Napoleonic wars, all the Great Powers had much to do in altering old fortresses or building new ones, which, according to the latest lessons of experience and of military science, were principally on a large scale. This led on all hands to a closer examination of the bastioned fortification hitherto dominant, the defects of which, long known and often insisted upon, had been newly illustrated in these wars. More effective and less exposed emplacements for the artillery, both for action on the country and for defence of the ditch; bomb-proof cover for men and stores; advanced works enabling the infantry to hold their ground outside the fortress, and to take the offensive; retrenchments for interior defence; protection of the masonry against breaching; a system of countermines ready prepared—these were the chief requirements. Choumara showed that they might be met to some extent without abandoning the bastioned trace, and in France this trace was adhered to, alike for forts and

* Yet Bousmard, one of the most distinguished officers of the French engineers, took a leading part in the defence of Dantzig.

for enceintes; as, for instance, at Paris, where, after long discussions, the enceinte recommended by General Haxo, and the forts advocated by General Rogniat, were ultimately combined.

Germany, following the lead of Prussia, took a different course. The bastioned trace had been already departed from in Frederic the Great's time, and there was now a reversion to the masonry works of the old German engineers, and an approximation to the ideas of Montalembert. Captain von Reiche gave early expression to this tendency in a work written in 1805, though published in 1812 (*Der Befestigungskunst, hergeleitet aus der gegenwärtigen Art des Angriffs und der Vertheidigung*). 'Vauban's great renown, a weak proneness to imitation, and the opinion that has hitherto prevailed, that no great engineer could spring from the soil of the Fatherland, have all,' he says, 'contributed to make us abandon the excellent ideas of our forefathers, and blindly follow the foreigner.'

In the instructions issued by General von Rauch, the head of the Engineer Corps, for the preparation of projects, in 1815, it is said: 'In all new works it is absolutely necessary to take account of improved methods of fortification, better suited to the conditions than those hitherto in vogue, and especially not to adhere rigidly to any of the older systems.' The value of detached works is pointed out. They should be so placed as to intercept the prolongations of the principal fronts of the enceinte. If they lie beyond effective musketry range, they should be provided with bomb-proof keeps, and be flanked by caponiers or counterscarp galleries. There should also be defensible barracks as keeps in the gorges of the bastions.

Between 1817 and 1830 Colonel Aster fortified Coblentz, occupying the commanding positions by groups of works; and at the same time Cologne was strengthened by five detached forts, about 565 m. in front of the enceinte, and 1,130 m. apart.* In 1827 Major Brese prepared a project for Posen, comprising a citadel and a main enceinte. The latter consisted of detached bastions, with keeps and caponiers, occupying the dominant sites, and connected by lines of rampart. This became generally known as the 'new Prussian system.' Between the views of General von Aster, who was head of the Engineer Corps from 1837 to 1849, and those of General Brese, who succeeded him, there was a broad distinction. The former looked upon the command of the foreground as the principal point, and rating the forts above the enceinte, he allowed the strength of the works to decline according as they lay further back. Brese held, on the contrary, that the innermost line

* Six new forts were interpolated in 1841-7.

should be the strongest, to compensate for the diminished strength and energy of the garrison.

In a memoir written in 1844 upon the new method of fortification, General Brese gave four remarkable examples from recent sieges, corroborative of its chief principles :

(1) Berg-op-Zoom (1747), suddenly stormed after 63 days' defence; showing the importance of a retrenchment to check troops who may penetrate by a single breach, and the need of low flanking fire.

(2) Saragossa (1808–9) ; showing, by the obstinacy of the defence of its houses until artillery was brought to bear upon them, that masonry keeps are of great value, if well screened and properly flanked.

(3) Dantzig (1807) ; where a block-house in the re-entering place of arms, being covered from the batteries of the besiegers, compelled them to have recourse to a mine attack, and delayed them 15 days in getting possession of the covered way.*

(4) Colberg (1807) ; where a detached work, hastily thrown up at a distance of 1,125 m. from the place, detained the enemy 44 days, owing to the vigorous offensive action of the infantry of the garrison.

The general disposition of works adopted in view of these instances was as follows :—The most important points of the ground were occupied by detached forts, about 600 m. apart, consisting of defensible barracks with several tiers of casemates, covered by earthen ramparts in front, which were flanked by caponiers or casemated batteries. Their covered ways were provided with masonry block-houses and a system of countermines. The body of the place, 375 to 600 m. in rear of the forts, was composed of similar but stronger works, connected by long and simple lines with blunt salients. The casemates flanking the ditches were exposed to direct fire only from batteries on the crest of the glacis, which were necessarily much inferior to them in number of pieces. The escarps were usually detached walls. Numerous hollow traverses were provided on the ramparts, and shelter-casemates behind the ramparts, so that troops might be able to hold the works unrelieved. This kind of fortification fully satisfied the various requirements of that day. It was very favourable to the offensive action of infantry. It afforded good artillery positions, especially on the long fronts of the enceinte, which could not be enfiladed ; while the casemates of the keeps and defensible barracks served for covered fire from howitzers. The block-houses and countermines in the covered way, and the keeps

* This instance was particularly referred to by Napoleon in his letter of instructions for Carnot's *Treatise on the Defence of Fortresses* (*Correspondence*, June 17, 1809).

in the works themselves, allowed of a most obstinate close defence. The caponiers and flanking batteries were hidden from the besiegers' distant batteries, and were more than a match for those that could be made on the glacis or in captured outworks.

But just at the time that the new Prussian system was beginning to take shape, a fresh factor presented itself in artillery. At Woolwich, in 1824, a detached wall, screened by a counterguard, was breached by 2,100 rounds from 8″ and 10″ howitzers,* fired with elevations of 10° to 21°. This experiment, rude as it was, showed that systematic breaching by indirect fire was possible, and attracted great attention, especially in Prussia, where masonry was being so largely used. General von Aster at once admitted that no one had hitherto supposed a wall could be breached by curved fire with reduced charges, and that if the results of the Woolwich experiments were borne out, considerable changes must follow, both as regards the construction and the attack of fortresses.

In 1826, the chief of the Engineer Corps, General Rauch, sent in a report, by desire of the Minister of War, upon the influence of the new kind of fire on existing works and on future designs. Since the introduction of fire-arms, no new discoveries—not even the invention of shells or of ricochet fire—had, as he declared, made so much sensation as these Woolwich experiments. In the course of three centuries the old walls and towers of the time before gunpowder had been gradually transformed into fortresses capable of considerable resistance; numerous writers had expended all their powers in contriving how to neutralise the effects of fire-arms by defilade, casemates, high glacis, and sunken walls; and the Prussian Engineer Corps had had the rare good fortune to be able to combine the results of the latest experience with the theories of the best writers, and to carry them out in practice, putting aside all prejudice and accepting whatever was good. And now suddenly these Woolwich experiments threatened to reduce the art of fortification once more to that state of impotence in which it found itself when cannon first came into play. These experiments, then, should be carefully scrutinised, to ascertain how far they were really trustworthy, and to follow out their consequences, in order that the fruit of the great expenditure incurred for the fortification of the fatherland might not be forfeited.

He went on to examine successively:

(1) What reliance ought to be placed on the Woolwich experi-

* Of these rounds, 1,200 were fired from 68-pounder carronades, and were solid shot. The howitzers fired shell. The range was 400 to 500 yards. In addition, 800 shot and 510 shell were afterwards fired to make the breach more perfect.

ments, and what was their actual result? This much, he allowed, seemed certain: that this new mode of breaching may in many cases be employed successfully without requiring a provision of guns and ammunition, or an expenditure of force, excessive and disproportionate to the object in view. But it would be desirable to ascertain by further trials what would be the effect of such a breaching battery against casemated keeps, the thick walls and numerous arches of which would probably offer a long resistance, while the breaching of the front of one casemate would by no means cause the loss of all.

(2) What changes would be brought about in siege warfare by the new mode of breaching? The breaching batteries would in future be made with less difficulty and less danger, and they could be as large as might be wished, instead of being limited by the length of the intended breach, or the space available for their construction. The breach could be made at an early period of the siege, and the threat of an assault held constantly over the heads of the garrison, and perhaps in urgent cases carried into effect. In many places, especially with fortresses built according to the older systems, the profile would be more favourable for indirect breaching than was the case at Woolwich. But a more important application than the breaching of the escarp by fire *across* the ditch, lay in the breaching of casemated flanking batteries by fire *along* the ditches they were intended to flank, wherever the prolongation of these ditches could be taken up by the enemy. The angle of descent would be less, and the charge consequently greater. On the other hand, he pointed out that it was becoming more and more difficult to storm a breach which was out of sight, and as to the state of which nothing was known; and that it was impossible so long as the covered way, counterscarp, keeps, and interior retrenchments were intact. Hence, as the siege works must all be carried out as usual, with the exception of the breaching batteries, the saving of time by their omission was the only real gain. Moreover, the narrowness of the ditches would allow only a few guns to be placed on their prolongations; with wet ditches and earthen slopes the new mode of breaching was inapplicable, and in any case the bringing up of the ammunition required for it was a laborious undertaking.

(3) What would be the influence of the Woolwich experiments on the art of fortification, and the value of the new Prussian works? At first it would seem that henceforward ditches should be as narrow and deep as possible, with revetted counterscarps and casemates for reverse fire. But such changes in existing works would be very costly and

would only partially attain their object, since with more guns and longer firing the besieger could make up for the diminished force of impact due to the greater angle of descent. Also the narrowing of the ditches would do little to prevent the besieger from firing along them at their flanking batteries. Besides, the new Prussian works were so designed that a breach would not lead to the capture of the place, but would only give the besieger the ground he could actually carry, while every foot beyond would be disputed.

Upon the whole he concluded that the new mode of breaching was still surrounded by doubts which could only be set at rest by further experiments; that it was in many cases too costly for use; and that, since it was just as applicable to revetment walls as to detached walls, it was more threatening to the old weak fortresses of neighbouring states, with their wide ditches and their lack of retrenchments, than it was to the Prussian works. Anxious endeavours to cover all masonry on account of this new means of attack he considered to be in the main unnecessary. So men are always apt (Colonel Müller remarks), when new factors first present themselves, to indulge the thought, 'It will not be so bad after all: it will still do.'

The Prussian mode of fortifying was soon followed in other countries—in Russia, Austria, and, owing to the influence of Brialmont, its most prominent vindicator, in Belgium. The French Engineers, however, continued to cling to the bastioned trace and to parapet flank defence; and notwithstanding their high training and their practical experience in sieges, they did little to advance the art of fortification. Their exclusive devotion to one type made them regard everyone as a heretic who (like Choumara, for instance) ventured to depart from it in any degree. The new German tendencies they ascribed to sentiment, and in support of this Blesson's statement was quoted, that 'since 1814 men in Germany have wanted to be German above everything, and have therefore renounced the bastioned fortification like everything else that bore the French name.'

The chief steps in artillery during this period were the increased use of heavy howitzers, and the introduction of shell-guns. The former (25-pounder and 30-pounder) had been used in the eighteenth century, but had fallen into neglect until the Woolwich experiment again drew attention to them. The latter, proposed by Captain Paixhans, were tried for the first time at Brest, in 1824, with great success. Howitzers of 23-cm. were brought into the Prussian siege train in 1831, and shell-guns of the same calibre in 1841. Howitzers and shell-guns of 28-cm. were afterwards adopted. Hand-mortars were introduced into Prussia in 1837 for close defence, especially from loop-holed walls. By the employment of hollow shot increased accuracy and range were obtained, owing to their eccentricity. In 1850, fortress shrapnel was introduced.

The effective ranges at this time were, for enfilade fire with heavy pieces, up to 1,500 m.; for ricochet fire with howitzers and shell-guns, up to 600 m.; for counter-battering, up to 450 m.; for high angle fire with light mortars, up to 600 m.; with heavy mortars, against extended objects, up to 1,200 m.; for breaching by direct fire, up to 300 m. Important experiments in direct breaching took place at Metz and Bapaume, confirming the method of operating by horizontal and vertical cuts. At Coblentz (1856) and Schweidnitz (1857) experiments were made in indirect breaching, or rather demolition, which showed that it could be applied satisfactorily against casemates at ranges of 470 to 750 m., and with elevation of 10°. Still engineers continued to neglect to screen their walls from it, and many writers (*e.g.*, Zastrow, Simon, and Rüstow) threw doubts on its efficacy where the conditions were unknown and the effects could not be observed.

Increased attention was paid to the composition of siege trains. In France the siege train was gradually increased to 200 pieces, in Austria to 220; while in Prussia, in 1853, it numbered 268 pieces, viz., 124 guns (15-cm. and 12-cm.), 33 howitzers and shell-guns (28-cm. and 23-cm.), 51 heavy mortars (28-cm. and 23-cm.), and 60 light mortars.

But during this period scarcely anything was done for the advance of the theory of attack. The few books of instruction which appeared on this subject, such as those of Aster and Sonntag, however copious in detail, were little more than a repetition of the precepts of Cormontaingne and Bousmard. Until 1860, Vauban's system of attack upon a bastioned fortress was the only one taught in the Prussian military schools. The artillery-attack of a polygonal front was fully dealt with by Simon (*Von der polygonal-und Kaponnier-Befestigung*, 1856), but the adoption of rifled guns soon made his work obsolete. Bombardment found a strong advocate in General De Blois, of the French Artillery; but the weight of authority was against it, on the score of ineffectiveness rather than of inhumanity. Its power was increased by the introduction of shell-guns and heavy howitzers, and was illustrated by the capture of Sveaborg and Bomarsund in 1854.

As regards the infantry defence, the views previously current were in the main unchanged; but opinion was generally in favour of heavy sorties in the early stages of the siege. 'Nothing,' wrote Simon, 'is so mischievous for the defence as mistrust of coming to close quarters with the enemy, and especially at the beginning, when the moral force is gauged and determined in the first contact with the foe. It is a chief rule for the defence, therefore, not to be too prudent about sorties, or too economical, especially at the beginning of the siege. The necessity of abstaining from them shows itself plainly enough when the time comes for it.' In the later stages small sorties were recommended, chiefly for the destruction of the siege works.

The principles of the artillery defence of bastioned fortresses remained as before. Smola (*Handbuch für K.K. Oesterreichische Artillerie Officiere*, 1839) wrote: 'It is a settled point that artillery combats are mere waste of blood and ammunition, that nothing is decided by them, and no time is gained. The true object of the artillery action is to hinder the approach of the sap, the building of the batteries, and the repair of damaged embrasures. The defender must protect his guns, therefore, from the enemy's fire as well as he can, and withdraw them if the enemy concentrates his fire on them; but he should immediately appear elsewhere, for which purpose light guns on high carriages are necessary.'

So also Simon, in dealing with the defence of a polygonal front, showed little faith in the power of the defenders' artillery to hold its own against the attack. The difficulties of the latter, he held, lay chiefly beyond the third parallel, and the besieged should reserve their strength for that time. General von Brese, however, thought quite otherwise. The fortress artillery, he said in 1850, should keep up the combat with the besiegers' batteries until they were completely overpowered; there would still be guns enough for the later stages of the defence. The long lines of polygonal fronts favoured their efforts; though they favoured still more, as he considered, the close defence, in which the besieger would be enveloped by casemated works. Detached forts were less suitable for artillery action, and, in fact, corresponded generally to bastions. Their keeps, however, could take a part in the engagement, and this part became more and more important as the attack advanced. The defence of Sebastopol not long afterwards strikingly demonstrated how obstinately the artillery combat might be maintained with long, unenfiladed lines, and abundant means.

Fourth Period.—Since the General Introduction of Rifled Weapons.

Several new factors have recently entered into the general problem of fortress warfare. Besides rifled guns, these include the following:

Breechloading rifles, which are chiefly favourable to the defence, as increasing the risk of executing siege works and of attempting assaults; railways and telegraphs, which allow supplies to be rapidly thrown into threatened fortresses; the electric light, which deprives the besiegers of the cover of night in their nearer operations; balloons and pigeons, which assist observation of the enemy and communication with the field armies outside; and lastly, universal compulsory service, which furnishes masses of men which can be converted into armies under shelter of fortresses, and can be used either for their attack or defence. But it was rifled artillery which exerted the most immediate and most profound influence upon fortification and fortress warfare.

I. (1860–70.) Rifled guns (8 to 15-cm.) were earliest introduced, rifled mortars and howitzers later. The weight of their elongated shot was about two and a half times that of spherical shot of corresponding diameter. Their effective range and their penetration was at least doubled, while the explosive action of the shells increased their effect enormously, both on earth and masonry. The conclusions deduced from numerous trials in Prussia were that enfilade fire was now practicable (with large calibres) at 3,000 m., ricochet at 1,800 m., and counter-battering (*i.e.*, dismounting by direct frontal fire) at 1,200 m. Experiments at Silberberg in 1869 proved that indirect breaching up to an angle of descent of 7° could be made use of, even where the object could not be seen or the effect observed.

The siege of Düppel, in 1864, afforded the Prussians a good opportunity of testing their rifled artillery, and in 1865 they reorganised their siege train. The new train (with which the sieges of 1870 were begun) was composed of 320 pieces, viz., 200 rifled guns (15-cm., 12-cm., and 9-cm.), 32 howitzers and shell-guns (28-cm. and 23-cm.), 48 heavy mortars (28-cm. and 23-cm.), and 40 light mortars (15-cm.). High siege carriages were adopted for all rifled guns.

The siege of Düppel proved that, against rifled guns, block-houses, keeps, &c., must be much better covered than hitherto, and that fire, even at such ranges as 4,500 m., could not be disregarded. It became necessary to reduce keeps to a single tier of casemates, and to avoid placing caponiers and flanking-batteries at the ends of ditches whose prolongations could be taken up.* After long discussion it was laid down in 1869 that:

(*a*) Salient caponiers must be so protected that the cordon of their front walls is covered from shots coming at right angles to them with

* Here the English engineers were in advance of the Germans, and this point was carefully studied in the new works for the defence of the dockyards designed in 1859. (*See R.E. Professional Papers*, ix. 135.)

an angle of descent of 7°, whereby the lowest point of impact will be covered against an angle of descent varying from 11° to 15° according to the height of the surface of wall to be hit.

(*b*) The conditions of cover for the keep are similar; the cordon is, as far as possible, to be protected against shots at 9° of descent.

From this it followed that the keeps must be pushed up so close to the covering parapet, or must be sunk so much below it, that they could no longer fulfil their former chief function of sweeping the interior, and the terreplein of the work; still less could they take part in the artillery defence. The consequence was the total abandonment, after a time, of the keeps hitherto in use. Traverses, especially hollow traverses, had to be more largely provided on the ramparts. On the other hand, the covered way lost much of its importance, and was either reduced to a mere patrol path, or (with detached forts) omitted altogether. The increased range of small-arms allowed the main parapet to serve instead of it as regards musketry fire, while in face of rifled guns palisading was useless, and it was consequently exposed to inroads at night. In the case of the forts, sorties could be made from their gorges.

The distance between the chain of forts and the fortress itself had to be considerably extended. At first only about 600 m., this distance had grown in Germany to about 1,400 m., after shell-guns came into use; while in the works of Paris (1841) it varied from 1,500 to 3,000 m. The forts of Antwerp (1859) were placed at 2,500 to 3,600 m. from the enceinte; but by 1869 Colonel Brialmont was of opinion that the distance ought to exceed 4,000 m., so as not to allow the enemy to come within 7,000 m. of the place. He still considered that the intervals between the forts should be normally about 2,000 m. (as was the case with the Antwerp forts), but would increase this on occasion to 3,500 m., if intermediate redoubts were provided.

In France, a voice was raised here and there against the bastioned trace, but it continued to maintain its ascendency. Prévost de Vernois, indeed, criticised Cormontaingne, but only to fall back on Vauban; and Noizet published, in 1859, a book on fortification which might, as Brialmont said, have been written in 1740. A commission was appointed in 1861 to consider the changes required by the introduction of rifled artillery. They recommended hollow traverses upon all faces that are exposed to enfilade, but the cost of these for the numerous fortresses in France was so great that the war ministry shrunk from it. To give protection against indirect fire was still more difficult, and men preferred, therefore, to embrace the comfortable and prevalent opinion that its effect in practice would be small. For the more important places a few detached forts were decided on, especially at Metz; but these were mostly unfinished in 1870.

The earliest experience of the influence of rifled weapons was afforded by the sieges of Gaeta, Charleston, and Düppel. General von Prittwitz and Colonel Brialmont were the chief writers who during this period dealt with the new conditions of siege-warfare. The principal things to be noted are the stress that was laid on infantry fire, to support the attack on one side, and to hinder it on the other; the increased distance of the siege batteries (up to 3,750 m. for enfilade, and 4,500 m. for bombardment, at Düppel); and the first mooting of the question whether a first artillery position at a distance would not be necessary in future before a besieger could build batteries at 900 to 1,200 m. from a well-equipped fortress.

When these batteries were once built, Brialmont adhered to the old opinion that the fortress artillery should avoid any general engagement with them. Overrating the mobility of the arm when the fight has once begun, he hoped much from the action of ambulant pieces firing over the parapet. Von Prittwitz, on the other hand, urged, as General von Brese had done, that the earlier part of the siege was the true time of action for the guns, and they should fight as long as possible; later on, musketry came more prominently into play, and it was foolish, therefore, to reserve them for the final stages.

In the case of a large fortress covered by detached forts, Brialmont was the first to point out that the artillery defence should be carried on by batteries in the intervals between the forts, rather than by the forts themselves. In common, however, with other writers of authority, he regarded the systematic attack of such a fortress, if well garrisoned, as an impossibility; and believed that assault, however bloody, would have to be adopted in preference. The difficulties of a regular siege led other writers to recur to bombardment, which it was recognised that railways and rifled ordnance had done much to facilitate. In the winter of 1869–70, the General Inspections of Artillery and Engineers in Prussia formed a mixed commission, which worked out in detail the attack of a fortress, with detached forts 1,700 m. apart, and 1,875 m. in front of the enceinte. Three of the forts were simultaneously attacked, and then the enceinte itself. The necessary siege train was estimated at 400 pieces.

But the war of 1859, and still more that of 1866, had drawn attention to field operations rather than to sieges; the lesson of Sebastopol was forgotten, and some people even fancied that fortresses had lost their value. The difficulty of bringing them up to a level with the new weapons, and the doubts felt as to the importance of so doing, caused them to be modified in only a very trifling degree; and in like manner the art of sieges itself received much less attention than the handling of troops in the field. Hence the conduct of the attacks in 1870 was a mixture of old principles and new rules, which had to receive many modifications in the course of the war. On both sides, also, the system of rifled ordnance was defective and incomplete.

II. (1870–1880.) The widespread disparagement of fortresses in general, a sense of the critical position of the smaller places when opposed to the new artillery, the information received as to their insufficient garrisons and equipment, together with some over-estimate of the effect of rifled guns, led to the idea that a mere cannonade with field pieces, with or without an assault, would probably lead to their surrender. This was tried in several cases in the Franco-German war, but without success, except in two instances—Marsal and Rocroi, the former of which places had only one artilleryman in its garrison.

Bombardments with siege guns proved very different in their results, and led directly or indirectly to the surrender of several fortresses. One evidence of their effectiveness is to be found in the exaggerations of French writers as to the number of shells actually fired. Colonel Prévost (in most cases following the commandants of the fortresses in question) gives the number of shells thrown into Toul as 12,000 instead of 4,000; into Verdun, 30,000 instead of 7,570; into Schlettstadt, 10,000 instead of 2,082; into Thionville, upwards of 25,000 instead of 8,600; and so with other places. But these bombardments also were at first undertaken too hurriedly and with inadequate provision, and failed of success (*e.g.*, at Toul and Strassburg).

The chief instances of successful blockade were Metz and Paris, and of systematic attack, Strassburg and Belfort (all of which are noticed at some length). At Paris we have an example of the first stage of the attack upon a great modern fortress, and for the first time we meet with batteries outside the forts in the intervals between them. The advantage of these positions was not fully realised, or made the most of; but, nevertheless, such batteries as there were were found very difficult to silence. To carry on the sap attack according to the old system, as was done at Strassburg, is now possible only when the defence is almost absolutely passive. Hence no rules for the future can be deduced from that siege. Indirect breaching was practised there for the first time in actual warfare, with good results under difficult conditions. At Belfort the defenders had three and a half months for preparation, which they turned to good account. Blindages, traverses, and other works were skilfully and substantially made, and the artillery armament was no less carefully executed. Particularly worthy of remark was the good cover provided for the guns, and the arrangements made for giving them great elevation, whereby ranges of 4,000 to 6,000 m. were attained. When the siege began, the outlying positions occupied by the garrison proved very valuable. They were in some cases very exposed, and were weakly and unskilfully defended, so that they were quickly carried when assaulted; but, nevertheless, they kept the attack for a long time at a distance from the works, partly because the besiegers were too weak to take the offensive, and partly because they were intimidated by the resolute attitude of the defenders. The well-directed and judiciously employed artillery fire of the fortress contributed no less to the same result. The offensive action of the infantry of the garrison soon subsided, and was very feeble, considering the weakness of the investment line: it fell far short of the performance of the artillery.

The general result of the war of 1870 was to show the weakness of small fortresses exposed to fire from all sides. Even the larger places which had no detached forts were seriously enveloped. The forts themselves possessed all the disadvantages of the small fortresses in an aggravated form, so that their artillery defence was soon extinguished, and their distance from the place (2,250 to 3,000 m.) was not enough to secure it from bombardment. On the other hand, the siege artillery fell short of what was required of it. Greater range was often wanted. The effect of shots upon earth and masonry was insufficient, and demanded too prolonged a fire. The 12-cm. and (long) 15-cm. guns in particular gave little satisfaction, and the smooth-bore howitzers required to be replaced by rifled pieces.

The chief conclusions drawn from the experience of the war as regards fortress construction were as follows:

Earth is the main means of cover. Masonry must face the enemy as little as possible. Security from assault, therefore, is to be attained chiefly by high counterscarps, the value of which has considerably increased. All masonry facing the enemy must be covered completely against an angle of descent of 15°. The most careful arrangements must be made for the service and protection of the guns, as well as for the storage and supply of ammunition. The casemates for men and stores must be in the reverse of the rampart. To escape enfilade as much as possible, forts should have blunt salients and short flanks. The fronts of the enceinte should be long and straight, and outworks should be discarded, so as to lessen the depth of the target offered to the enemy's fire. Little can be made of retrenchments, since keeps of the old type are inadmissible; but this is of less importance, since the decisive struggle now takes place at a distance.

The German forts built since 1870 have been simple lunettes, with counterscarps 6 to 7 m. high, and detached escarp walls 4 to 5 m. high, organised according to the conditions above-mentioned. In France, although Colonel Prévost, in 1872, still advocated the bastioned trace, the long-despised polygonal trace was adopted for the new forts. These have counterscarps 7 m. high, and escarps 6 m. high, covered against an angle of descent of 15°. Parados and capital traverses cover the ramparts against reverse or enfilade fire up to 10° of descent, and there are numerous casemates under the ramparts. A characteristic feature in the French forts (which has been adopted quite recently also in Germany) is the provision of an upper and a lower rampart, the former chiefly for musketry, the latter for artillery: an arrangement of great importance as allowing of the simultaneous fire of infantry and artillery at the moment of assault. The covered way consists of a patrol path, 2 to 4 m. wide in Germany, 8 m. wide in France; the latter affording a much better infantry position, whether for fire only or for sorties. In neither country have the new forts keeps.

The employment of iron-plating was strongly urged immediately after the war, and it was argued that one gun so protected would be able to make head against six, eight, or even ten siege guns. But it was soon recognised that, to secure them against assault, iron-plated batteries or turrets would require to be inside the forts, and that there were only a few cases in which the latter needed to be strengthened so considerably and at such great cost. Hence there are not more than a dozen turrets in the whole of the fortresses of Germany, and only a few iron-plated caponiers for the enceintes. In the French forts iron has been more largely used, shields being provided for several guns on the ramparts. Shields, however, are inferior to turrets, because the ports of the latter can be averted from the enemy, so that the guns in them are more likely to remain serviceable in the later stages of the siege, when they are of most value.

In order to secure places absolutely from bombardment, Brunner and Brialmont have recommended that the chain of forts should be thrown forward to about 7,000 m. from the enceinte. But this extends the length of the chain, and increases the number of works, or the intervals between them, and calls for a larger garrison. Hence it has been justly argued in Germany that 5,000 m. should be regarded as a maximum, and the distance of the forts most recently built is actually between 4,000 and 5,000 m. The intervals between the forts are in

Germany not more, if possible, than 4,000 m., which will give nine or ten forts for the whole circuit—a number which is not excessive. The new French forts are :

At Verdun,	4,000–6,800 m. from the enceinte, and	3,100–4,900 m.	apart
„ Toul,	4,600–4,900 m. „ „ „	4,200–9,700 m.	„
„ Belfort,	3,200–4,100 m. „ „ „	8,000–11,500 m.	„

At Paris they are disposed according to the group system developed by Brialmont, and are 9,500 to 15,000 m. from the enceinte, and 5,000 to 18,000 m. apart. Mutual support is therefore excluded, and even the defence of the intervals between them. They must fight independently, and are larger and more heavily armed than the German works. The whole chain consists of forty-five works, armed with 2,000 guns, and having a circumference of 130 km.

In Germany it is not considered that strength and the power of independent defence necessarily demand size. Three types have been got out, for 20, 32, and 54 guns respectively, and for infantry garrisons of 250 to 500 men. Brialmont, on the other hand, advocates large forts, with 400 m. of front, and an armament of 100 guns; and considers that the intervals may be extended to 5,000 or even 6,000 m. On the flanks of the forts wing-batteries for 8 to 12 guns may be got ready in peace time, but the intermediate batteries and field works for infantry must be left till the siege.

It has been often proposed to dispense with the inner enceinte, and trust wholly to the chain of forts; but this proposal has nowhere found acceptance, and the objections to it have been fully stated by Brialmont. A special character is given to the fortification of the east frontier of France by a chain of barrier forts. These are adapted to the varieties of the ground, with much freedom in the handling both of trace and profile. Their details correspond to what has been already described. They were at first made small, for 150 to 500 men and 25 guns; but the later ones have been much larger, some of them for 1,500 to 2,000 men and 80 to 100 guns. Altogether these barrier-forts require 18,000 men and 800 guns, or as much as a large fortress.

In artillery, the new pieces, introduced in Germany to meet the wants experienced in the war of 1870, are the 15-cm. hooped gun, the heavy 12-cm. gun, the short 21-cm. gun, and the 21-cm. mortar. The first and last of these are intended to be used for bombardment at ranges of more than 3,000 m.; the first and second for enfilade at 4,000 to 5,000 m., and for counter-battering (which has become more difficult since embrasures have been abandoned) at ranges under 1,500 m. as also for direct breaching, whenever there is opportunity for it.

Ricochet fire is possible with all pieces, up to 2,000 m. or more; but the short 21-cm. and 15-cm. guns are best suited for it, as they give the most highly-curved trajectories. They are also intended for indirect breaching. For this it is found that, with angles of descent exceeding 8°, demolition fire must be substituted for groove-cutting, and may be effective up to 20° or 25° of descent. With the exception of some smooth-bore mortars, and smooth-bore guns for flanks, rifled pieces have been generally substituted throughout the fortresses. In some of the French places, 19-cm. naval guns have been mounted. The German siege train, as reorganised in 1875, consists of 400 pieces (viz., 40 hooped 15-cm., 120 short 15-cm., 120 12-cm., and 40 9-cm. rifled guns, with 40 21-cm. rifled mortars, and 40 15-cm. smooth-bore mortars). It is calculated for the attack of three detached forts, and afterwards of the enceinte of a great fortress. The Austrian and Russian trains are of the same number of pieces. Trains of 500 pieces are in contemplation in France. The German pieces are much more effective than those used in the war. By increasing the initial velocity, and by the use of long shells, their accuracy has been much improved, and their service is better and more rapid.

Immediately after the war, extreme stress was laid on great length of range, just as we have heard so much about long-range musketry fire since 1877. But this has lessened lately. It is only in special cases that very long range is wanted; and the pieces that have the longest range are not those which are most useful for bombardment. But no limit has yet been reached in the progress made by artillery, and ten years hence we may have to reckon with factors which at present lie quite outside of our field of view.

The success of bombardment in bringing about the surrender of the smaller French fortresses caused it to be highly rated as a mode of attack after the war. The French denounced it as barbarous; but they had themselves used it against Rome and Sebastopol, and even from Montmartre against La Villette. The first writer to discredit it, however, was Colonel Prévost, who, in 1872, showed that the loss of life occasioned by it was quite inconsiderable. Hence he argued that, though allowable as an aid in a regular siege, it is by itself ineffectual, and therefore unmanly, when a place is determined to hold out. The French official instructions for the service of artillery in a siege (published in 1876) recognise it as lawful in all cases; and the extension of the new works of defence, both in France and Germany, has been influenced by the fear of it. But in Germany the sounder opinion has recently gained ground, that with well-organised works bombardment is not formidable, especially where the area is large.

The great difficulties and delays which must attend the regular siege of a large fortress of the modern type, and the rapidity with which war is now carried on and campaigns are decided, have led many writers of authority to turn to assault as the simplest and best mode of capture. It is argued that, with the help of a violent cannonade, and such aids to storming as can be quickly brought up, the obstacles of an isolated fort can be overcome; and, heavy as may be the losses, they will not exceed those attending a long siege. But the experience of the war of 1870 is quite against this view. The one attempt made at Toul failed; and, in spite of favourable conditions, the assault of the Paris forts was never ventured. The preliminary cannonade will put the garrison on the alert, and to bring up the storming-appliances without attracting notice is quite impossible. So many men are needed, and so much time, that the enemy's fire has full opportunity of checking an operation, which is liable to be frustrated by any accident, and is dependent on leaders who may be killed at any moment.

The project of systematic attack worked out by the Prussian mixed commission in the early part of 1870 was revised after the war, and, together with a project of defence, was issued to the troops in 1874 for general information and criticism. So far as artillery and engineer operations are concerned, these projects have formed the basis of all subsequent discussions, private or official. The subject has been recently handled by Schmölzl, Popp, Mollik, Ratheau, Bonin, and Wolf (and their works are briefly noticed).

Three varieties of regular siege may be distinguished: the *systematic attack* in its complete form; the *abbreviated attack*, where the assault is delivered before the siege works have been pushed fully home; and the *accelerated attack*, where the siege works are carried on more rapidly than usual, less methodically, and with a larger use of force. It has been urged that, in order to take the besieger by surprise and to decide matters quickly, it is better not to have any definite distant artillery position. But the ground for the decisive batteries is so near the place that, to gain possession of it, the support of more distant batteries will almost always be necessary. Therefore, although the first batteries should be made as near as may be possible, others will afterwards be pushed forward nearer, even if there are not sharply-marked successive positions. Usually, with a strong garrison the distance for the first artillery position will be 3,000 to 4,000 m.; with a weak garrison, under favourable circumstances, 2,000 to 2,500 m. The second position will be between 750 and 2,000 m. In advance of this, in the parallels, some 9-cm. pieces will probably be needed to dismount particular guns, and to drive away riflemen from sandbag loopholes; as well as light mortars in large numbers.

As regards the artillery defence, a decisive encounter with the batteries of the first artillery position is not possible. All that can be done is, while endeavouring to draw off the batteries in general from their main objects, to concentrate a fire from various points upon the most important and most threatening group of batteries. There should be similar concentration against the batteries of the second artillery position, with a large employment of high angle fire. The main principle for the defenders is no longer the saving of strength and material for the later stages of the fight, but their fit use in the earlier period, when they have room for movement and some freedom of initiative. Some pieces, however, must be preserved to meet assaults, to check the advance of the sapheads, and to oppose the breaching batteries.

In the case of fortresses with detached forts, the questions have been raised: How far will the placing of guns in intermediate batteries, desirable as it may be in an artillery sense, be practicable on broken ground? How will the departure from normal arrangements which may be necessary in such cases affect the artillery? How will the infantry be handled, and how far must the artillery bend to its requirements? As regards these points, it may be remarked that the amount of work to be done, and the shortness of the time, will always restrict indulgence of the preference for intermediate batteries, and oblige men to mount as many pieces as possible in the forts and their wing-batteries. The commanding positions of the forts will also make them in some respects the best places for guns. The intermediate batteries will not be built and armed until the direction of attack is known, and how far there will then be time for them is questionable; so that strongly-armed forts will be very advantageous. Besides, a numerous artillery in the intermediate batteries will require a strong force of infantry to guard it against troops who may pass between the forts; and this infantry will be much exposed to fire, and will forfeit all offensive action. It seems probable, therefore, that the ideal of artillery defence is only capable of realisation with an unusually strong garrison, and that in other cases the placing of guns in intermediate batteries will only be feasible where the ground affords supporting points and cover, which admit of a weak guard. As regards the pieces, those intended for direct fire and wide lateral range will be best placed in or near the forts; those to be laid indirectly, and to fire in one direction, in the immediate batteries. Mortars may be anywhere, but usually behind the gun-batteries. The sites of the batteries must be chosen with an eye to their protection against attack. If the ground is uniform, it is much better that they should not be in front of, or even in, the general line of the forts, but several hundred yards behind it. The fighting position for the infantry can then be placed in that line, or in front of it, and the reserves can be kept near the batteries.

But, both as regards attack and defence, there is much that is uncertain. Ideas on fortress-warfare are undergoing a complete revolution, the result of which is not yet apparent. A little while ago there was a general predilection for those modes of attack which promised to give escape from a regular siege. But this has lessened with discussion, and consequently the formation of rules for the conduct of the systematic attack has been recently taken up with zeal. Though the bases for it have been laid and accepted, there still remains great divergence of views as regards particular points; especially the tactical use of troops, many questions bearing upon which have hardly been touched.

E. M. L.

PAPER III.

THE ARTILLERY DEFENCE OF A FORTRESS.

By Lieut. A. P. Codd, R.E.

This is generally admitted to be a subject of the greatest importance at the present day; of so great importance and so wide a scope that it is scarcely possible to enter into it very fully in the space now at my disposal. I shall therefore confine myself to the consideration of the leading principles which should guide us in the disposition of our artillery defences on an extended line of *detached forts*.

Thus I am not dealing with any system of fortification. The defensibility of an important fortress lies in its detached forts, and the enceinte will be seldom relied upon to offer a prolonged defence, only, indeed, where the natural strength of the position is very great, or from political considerations where a central fortress represents the defence of a kingdom. Thus at Antwerp all the skill and ingenuity of engineering art has been applied to produce a defensible system, which does not rely upon prominent natural features of ground. But the most extended enceinte must be confined, when compared with the extent of the ground available for the besiegers' batteries firing at 2,000 to 4,000 yards range; so that his power of concentration of fire on one or two fronts must soon silence guns worked in the open or even temporary casemates. Our space for arrangements of trace and profile is so limited that we can no longer rely upon those for the protection of guns, but only on strength of material; and casemated batteries are, as a rule, expensive luxuries for land fronts.

Thus the artillery defence of the main body of a fortress is not likely to be prolonged, and we must depend upon the difficulties we can offer to the progress of the enemy's siege works and to his final attack upon the works. But the case is entirely different in the defence of a position strengthened by numerous detached forts, and we propose to consider how far the artillery defence may be conducted actively by the disposition of our guns in batteries, from which they may be shifted as required, and which take advantage of the features of the ground.

We must first arrive at the functions of the artillery, and must therefore briefly refer to the various stages of the attack and defence. We have no important example of a regular attack upon a strong line of works under modern conditions of warfare; but we know that during the early part of the siege the besieger will act upon the defensive. He will strengthen his lines of investment, and allow the garrison to shatter their strength and become demoralised in executing unavailing sorties.

In the meantime, the front of attack, comprising three or four forts, will have been selected, and the artillery and engineer parks formed, so that active operations may be commenced so soon as the superiority of the besieger is finally established.

Then follows the bombardment or artillery attack, undertaken with two objects: (1) to completely overpower and silence the defensive artillery, and (2) to demoralise as far as possible the troops exposed to this fire. To this, hitherto, a passive defence only has been opposed; the concentration of the enemy's fire on individual forts silences their artillery in a few days and thus prepares the way for the prosecution of the close attack. And how great demoralisation may result from the unexpected opening of a heavy artillery fire was shown in the panic produced by the artillery attack on Mount Avron before Paris; on the other hand, where good cover, permanent or temporary, is provided, the effect on the garrison, both in point of actual loss and of morale, is little or nothing, and it is generally assumed that bomb-proof cover will be available either in permanent casemates or in temporary blindages excavated in rear of the position or under the ramparts.

Thus the second object, referred to above, may be left out of consideration, and the first and most important function of the defensive artillery is to resist the artillery attack as long as possible. This is the artillery combat at long ranges; no other arms take part in it, and it is necessary for the besieger to gain the upper hand in it before he can prosecute the siege. It is the object of the defender to defer this period to the utmost.

This part of the subject may be called the distant or artillery defence; but the artillery has also its functions in the close or musketry defence which follows on the enemy taking up his second artillery position and advancing within the musketry zone, assuming that he has more or less silenced the defensive artillery. Two forms of close attack are open to the besieger, viz., the assault and the attack by regular approaches. In the first the heavy artillery of the defenders would play a comparatively unimportant part; the conditions would be similar to those of an attack on an intrenched position, strengthened by powerful works at intervals. The defenders would bring their field artillery into action, and it would be the province of such of their heavy guns as are still available to keep under, as far as possible, the fire of the siege batteries, at least until the assaulting columns are within 200 or 300 yards of the position. Recent examples have clearly proved that strong earthworks, resolutely held, are almost if not quite impregnable, even if they are of weak profile, provided we fulfil the main principles of infantry defence, viz. (1) complete observation of the foreground within the musketry zone, (2) maximum amount of clearance within this zone, (3) maximum front available for rifle fire. Thus in the case of an assault we depend upon rifle, not artillery fire.

But we must have artillery fire available, if we expect to delay the progress of the enemy's siege works; and *artillery must be reserved for this object; i.e.*, artillery that has taken no part in the distant defence must be at our disposal to concentrate its fire on the approaches. This, then, is the all-important part our artillery has to play in the close defence, and for it we must reserve a portion of our guns to be disposed on a totally distinct system from that on which we propose to organise our artillery for the distant defence.

I shall therefore consider these two separately, and commence with the *distant artillery defence* where the artillery depends on itself alone, instead of supporting and being supported by infantry.

Now the general principle on which I would organise the artillery defence is this: I would reserve a certain portion of the guns of the armament of a fort to support the close defence from batteries in the fort itself; but those guns intended to sustain the artillery combat should be disposed in batteries, permanent or temporary, between the works, whether for direct or indirect firing; and a system of active defence should be organised so that the guns may be shifted to positions in rear when the first position is rendered untenable. *Thus not a single gun from the fort should take part in distant defence.*

Now what is the present state of the question? In most of our own forts the batteries are intended to be armed on the ramparts, perhaps in Haxo casemates or Moncrieff pits; if guns are available intermediate batteries might be formed. In important works, iron cupolas might be erected in the keeps, and we learn that Brialmont intends to arm a battery behind the gorge of his large forts from which to direct a high angle fire over the front of attack.

The Germans have since taken another step in the direction I propose. In Captain Fraser's essay on the *Attack of Fortresses in the Future*, we find this sketch of the artillery defence; the forts will only mount such guns as can be thoroughly well covered, while a number of the defenders' guns, as well as a proportion of the artillery from works not engaged, will be posted in siege batteries near the line of forts, and connected with them by trenches, which guns, if hardly pressed, may be shifted into fresh batteries in rear. The case of the new German forts at Strassburg is cited; they are small, and only afford space for 14 or 16 guns on siege carriages.

The latest German system seems yet more definite; there are 'attached batteries' forming with the fort one defensive unit, and 'intermediate batteries' are to be thrown up before or during the siege. The former are to oppose the enemy's first position batteries, and the latter his second. It is also stated 'there is no cover on the ramparts for the armament which it is intended to withdraw into the attached batteries in case of the enemy's fire getting the upper hand.'

This, then, seems to be the latest development of the battery system of defence, but it is apparent that the idea of maintaining the artillery defence in the first instance from the works is not yet abandoned. But I consider that there are important objections to arming any batteries in the forts that are intended to engage in the artillery combat; they may be briefly stated thus:

(1) It is evidently a source of weakness to concentrate our guns in the forts, since the convergence of the enemy's fire on single points in an extended defensive line is very great; whereas the ratio of the lengths of the besiegers' and defenders' lines is comparatively small, so that our artillery would fight on more equal terms, if disposed along the whole line. Nor, unless our guns are advantageously placed at the opening, can we expect to avail ourselves of intermediate batteries after the forts are silenced; for at Paris, not only were the attached works silenced in a few days, but such single guns as the French brought forward into the subsidiary emplacements were invariably obliged to cease their fire after a few rounds (Blumé).

(2) The enemy are almost certain to be able to obtain from plans, &c., information concerning permanent batteries constructed in the forts, by which to regulate their fire, and the fort must be more or less conspicuous, so that the besieger not only knows how to calculate his aim but has apparent objects to aim at. If we strengthen our defences we but defer our defeat, as the strongest work exposed to the accurate fire of modern artillery must succumb; it would therefore

seem better to increase the inaccuracy of the enemy's fire by arming batteries in positions unknown previously. This it is almost impossible to do in or near a fort, but the natural features of an extensive position should afford numerous points.

(3) If we occupy the ramparts with Haxo casemates, we diminish the extent of parapet available for the close defence, and thus infringe an important condition of the latter.

(4) So long as artillery fire is maintained from the fort, *artillery fire will be drawn upon it*; then the besieger not only effects his object of silencing the defensive artillery, but he demoralises the garrison and damages the work generally, involving extra labour and loss on the part of the troops in executing the necessary repairs before the regular siege commences.

Thus it would appear that the German system does not dispose of these objections; the small artillery forts would particularly suffer from the concentration of fire that would be drawn upon them, while the front available for infantry defence would be insufficient. And as, according to the latest idea, the besiegers' fire must soon get the upper hand, especially as there is to be no cover on the ramparts, not only is the fort damaged so long as the artillery defence is conducted from it, but a great deal of labour and probable loss is incurred in shifting the guns into the 'attached batteries,' while needless elaboration is expended on the construction of the parapets, which are ultimately destined for the infantry alone.

Granting, then, that the artillery combat should be maintained from *intermediate batteries only*, let us briefly discuss some of the practical conditions of the question with reference to the following points:

1. The working and supply of the guns in batteries.
2. The form of battery to be adopted and its defence.
3. The sighting of guns for indirect firing from concealed positions.
4. The withdrawal of guns from the first position and their supply in a second.

(1) Here we meet with the first practical objection to the battery system. So long as the guns are in the fort, it is possible to convey the ammunition direct, under cover, from the main to the expense magazine, by galleries and lifts. But defence batteries must be supplied in a similar manner to siege batteries, and battery magazines must be constructed capable of holding sufficient rounds for a certain number of days' firing. We have, however, two sorts of battery to consider, viz., the attached and intermediate; the former, not more

than 300 or 400 yards distant from the fort, would be connected with it by trenches cut on the opening of the siege, and would have expense magazines supplied direct from the main magazine of the work.

A subterranean gallery could be constructed from this magazine to a point in rear of the gorge, from which the trenches could start. And here we should hardly be liable to more accidents and loss than if the batteries were on the ramparts. The artillery reliefs would also live in the fort.

But intermediate batteries must have field magazines, supplied from depôts in rear, and the reliefs must also occupy field casemates and blindages in rear of the position.

With all the stores of a large fortress at our disposal during the period preceding the attack, we should be able to render our batteries and magazines more secure than those of the attack, as regards the effects of artillery fire. Of course these batteries are disposed so as to take advantage of the ground, so that men and ammunition could proceed direct to them, at least at night, so long as the enemy holds his first artillery position only; but in some cases zigzags might be necessary from the nearest point of cover.

Thus, on the whole, the objection on the score of greater labour and loss involved in maintaining an active artillery defence is of small importance when compared with the advantages of the system.

(2) Now the functions of our artillery have been already referred to; our batteries have to sustain the artillery combat, and we assume that the enemy could not open regular siege operations in the face of a well-sustained artillery fire. Thus the batteries are not likely to be exposed to attack by sapping.

But circumstances might justify the besieger in venturing an assault or night attack. The field force intended to maintain an active defence might have been cut off, or driven into the place completely demoralised; the garrison might thus be of inferior quality and barely sufficient to hold the forts; or political considerations might demand the capture of the fortress at any cost.

But, whatever the cause, our batteries are liable to attack, and some, at least, must be made defensible with direct observation of the foreground, in order that, towards the final stage of the attack, volleys of case, &c., may be poured into the enemy's columns.

We should, obviously, utilise the *attached batteries* for this purpose, as their guns would sweep the ground in the immediate vicinity of the fort, and their own front would be flanked from the flanks of the work; and thus the defensive front of each fort would be increased, while a portion of the garrison could be spared to hold the connecting trenches and defend the batteries, even if we have not sufficient troops to hold the whole position in strength, and are thus unable to defend intermediate batteries.

With regard to the attached and exposed batteries, another objection to the battery system occurs, viz., *loss of command*. Provided we fulfil the conditions of musketry defence above referred to, we should decrease to the utmost the command of our works, in order to render them less conspicuous and save expense, by adopting a light profile, which can be applied to strengthening our batteries.

But the loss even of 10 feet or 15 feet command, while making little difference in our distant firing, ma yconsiderably decrease our power of observing the foreground. From low batteries our guns are able to direct a searching fire over the enemy's positions, but it may be difficult for them to sweep the ground in their front up to 400 or 500 yards.

Again, it is not easy to find a form of battery adapted for direct as well as high angle firing; for the latter, overbank fire would be most suitable, but with countersloping depressions, we should seldom be able to observe the ground in front, unless we excavate the interior of the battery and have our line of fire only a foot or two above the ground. Very low batteries of this type might be employed in some situations; otherwise we must use carriages on Moncrieff's principle or embrasures. The former are objectionable on account of their cumbrous nature and the consequent difficulty of shifting them.

The objections to embrasures are well known, and are increased by the fact that the defensive guns require a far greater radial sweep than those of the attack, each of which has its work cut out and its line of fire adjusted accordingly.

However, there can be no doubt that embrasures are most suitable where we desire to observe the foreground from low batteries, unless a more simple and more mobile form of carriage than the Moncrieff is devised for overbank fire; but they must have considerable splay, and should, if possible, be provided with iron shields, of sufficient strength to resist the penetration of ordinary siege train projectiles.

In any case, our advanced batteries (the attached) should be permanently and strongly constructed, as they would be exposed to the enemy's view, though less conspicuous marks than the forts, and thus contend at a disadvantage with the distant siege batteries, which need not provide for close defence, and which may occupy concealed positions.

Siege batteries may also be covered by screens, whereas it would obviously be impossible for us to throw up substantial screens in advance of batteries in the fighting line, as not only would they interfere with our observation of the foreground, but they might serve as temporary lodgments for the enemy. Such natural screens as a thin row of bushes, &c., might however be admitted.

Thus we see that there are practical difficulties to be met in the design of our advanced batteries, if, as is desirable, they are to support our line of resistance in case of an assault by direct fire. But we must also remember that the chance of an assault being made on a strong line, resolutely held by a large force, is a remote one; and as in any case field guns could be brought into action in temporary emplacements, where the nature of the ground would render these batteries too exposed, and monetary considerations prevent us employing iron shields, we must consider the distant defence of first importance, and retire our attached batteries to such positions, and so construct them, as would admit of their observing the flanks and gorge of the fort, though concealed from the enemy's view.

This would be the case with our retired and intermediate batteries; their fire would be directed from positions at least 400 or 500 yards in rear, over the crest of the position.

As we may be holding the whole position, we must so situate them that their projectiles directed on the enemy's batteries pass well above the troops engaged; there is, of course, an objection to firing over the heads of troops in front, but at least we are not worse off in this respect than the besiegers. Retired batteries would not participate in the close defence, except by directing an irregular fire over the field of attack; but they should, if possible, observe the crest of the position and the gorge of the works, so as to check the enemy in forming lodgments in our position or working round the flanks of the forts.

These batteries would be of temporary construction, similar to siege batteries, and thrown up in positions unknown to the enemy, so that his fire on them would at the best be inaccurate. If he found the range of one too well, the guns could be shifted to another battery, and I consider it doubtful whether indirect fire of this nature could ever be entirely silenced. The effect of the enemy's fire on such batteries would be too great to enable us to hold them very long if his fire once became accurate, as they would be of comparatively slight profile, and their interior would not be defiladed. On this point batteries on the ramparts of the fort have an advantage.

It would seldom be necessary to render retired batteries defensible; if we could hold them after the opening of the close attack, they would still be sufficiently in rear to render the chance of the enemy penetrating our advanced lines in night attacks from his trenches, and spiking the guns or otherwise damaging our works, a very remote one.

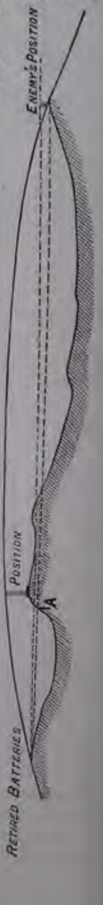
Still, in case of a successful assault, it would be better if they had fairly open ground in front of them, that they might check the enemy and serve to cover the retreat of our troops.

Now, to see more clearly the part retired batteries would play in the artillery defence, I will briefly describe the normal conditions of the artillery combat. Although the importance of our external batteries supporting the close defence is diminished by the fact that we have reserved a certain number of guns in the fort expressly for that purpose, yet it would seem advisable to strengthen the position by a few strongly constructed exposed batteries.

On these the enemy would probably, in the first case, concentrate his fire, and *eventually* silence them, or cause us to withdraw the guns. He would then prepare the way for his close attack by a vigorous bombardment of the forts, at the same time engaging our retired batteries. In this contest it is not likely that either side would incur fatal damage; but though our fire on the enemy's first position might be ineffective, our knowledge of the surrounding country would enable us to keep under fire the ground in the vicinity of his probable second position, and cause him great loss, if not entirely prevent him throwing up and arming his batteries. But assuming that this operation is successfully executed, and that the first parallel and regular approaches are opened, it would be difficult to direct an effective fire on so small a mark as a sap head, whose position continually shifts; thus our indirect fire can only be maintained on existing works such as the batteries and parallels. It would, therefore, seem advisable, as the siege operations proceed, to evacuate some of our retired batteries, even if not silenced, and take up a second commanding position in rear, out of rifle range, whence a direct fire can be poured upon the approaches, &c. These batteries would then divert a portion of the enemy's fire from the forts, from whose batteries the main opposition to the progress of the trenches is to be expected.

The success of the battery system must depend upon the skilful selection of the positions and the subsequent judgment displayed in choosing the opportunity of withdrawing them. In level sites, every dip and natural screen, such as trees, &c., must be taken advantage of to conceal retired batteries; or the reverse slopes of the position, or the crest of lower hills in rear must be occupied, provided always that the line of fire passes well over the position. Some positions may not admit of a good battery defence, such as narrow ridges falling steeply to the front and rear. Thus it would be difficult to make use of retired batteries on the Portsdown Hills, where there is not much depth in the position and no high ground in rear.

But after discussing all the theoretical conditions of the question, we are still dependent, for successful defence, on two practical points, viz., an efficient system of indirect aiming and the design of a suitable gun carriage.



(3) In the distant artillery contest it is evident that the besieger has the advantage, as we have seen his first position batteries, not intended for defence, may occupy concealed positions and employ natural or artificial screens, whereas the necessity of our having a clear foreground must expose all works advanced to the front of the position to view, while at the same time the enemy can adjust his fire according to the plans he probably possesses of our permanent works. But his fire from his first position on concealed parts of our works, such as caponiers or low batteries, will not be sufficiently accurate to demolish them. For this purpose he must take up the second position, and the question is whether we could so command the ground up to 1,000 or 1,200 yards distance as to hinder, if not prevent, the enemy developing his attack. Consequently, our first duty is to have an accurate knowledge of the ground up to 1,500 yards distance, and as much farther as is possible; to note the probable artillery positions; such prominent features as might guide us in judging the sides of the enemy's batteries and the ranges to them.

Our plans must be accurately contoured within this zone. With the assistance of range finders, or by triangulation, the position of siege batteries must be judged and plotted. Our advanced batteries, after estimating the range, would, of course, open fire directly. But we must transfer the line of fire to our retired batteries from the plans, and mark it on the platforms, or note such features in the ground in front as it cuts.

For sighting, however, the only information we have is the approximate difference of level between our own and the enemy's position and the range.

We must then either obtain our line of sight on the ground or on the gun by an attached scale; the first system would be most accurate, and might be applied to sites of the nature shown in the diagram:

The point A would be marked on the ground by adjusting a theodolite to the slope, or by running a level across the valley and levelling the vertical distance down.

If the difference in level was very small, we might level the sights and fire by judgment, according as we can obtain information as to the results of our firing from the forts or observatories.

But where there is considerable difference of level, unless we obtain the line of sight on the ground, an instrument of sufficient accuracy to read up to $\frac{1}{200}$ must be attached to the sights. This might be done with a level and a sight rod with a vernier working on a graduated arc, or bar.

On some such system we could no doubt maintain a fairly accurate, though slow, fire on points whose positions we know or judge, such as siege batteries or parallels; and when it appears that the enemy intend to take up a nearer position a more rapid and general fire would be kept up by judgment and trial, as we should then be better able to observe the results of our firing from the forts. But it is doubtful whether an indirect fire could be maintained to any advantage on points like the sap heads; these could only be assailed from batteries in rear, or from batteries in the fort reserved for this purpose. It might, however, be possible by rough triangulation from the forts and small intermediate bullet-proof observatories to plot an approximate plan of the enemy's siege works, by the help of which, and observation of results, shots could be directed from retired batteries.

(4) I have no doubt that we could move our guns within the position, certainly at night, in the open, so long as the enemy's are not within rifle range; the risk from chance shots would be comparatively small, and in very exposed places it would be needless to incur any great risk in withdrawing guns, as trenches could be cut. But when our exposed batteries become untenable the guns might be withdrawn, though if there is no good second position we must continue our indirect fire to the last.

We require a mobile gun carriage, more mobile than the garrison carriage, and less heavy than the siege carriage.

For the comparatively slight movements required it is evident that we do not require a carriage designed to traverse miles of road. The Moncrieff carriage is too cumbrous, but it would be a decided advantage if we could mount our guns in the exposed batteries on some disappearing principle, so that we could dispense with embrasures and yet command the foreground. The second position batteries would derive their supplies from the body of the place; and we must also remember that, though a second position would be of use as serving to divert the enemy's fire, in less important fortresses, the guns of the enceinte would be able to support the forts.

The space at my disposal is too limited to enable me to enter very fully into these points, but we must admit that a far more efficient artillery defence could be maintained from batteries than from the forts.

The idea of placing field artillery in field redoubts has long been abandoned on the same principles as those on which our heavy artillery should be withdrawn from the forts. Such practical objections or difficulties as I have alluded to could, I think, be met and overcome if the theoretical advantages of the system were once admitted. The first objection would arise regarding the insecurity of the guns in batteries as compared with the fort, but if an efficient system of indirect firing were adopted, there would be no occasion to expose our guns in advanced batteries. Nor is it intended to leave the forts entirely without artillery defence, and we can now consider how to dispose of such guns as we reserve for the close defence, whether or no we are supported by direct fire from the attached batteries or batteries in rear.

Now it is evident that we require heavy artillery to participate in the final operations of the close defence, if we would check the progress of the enemy's approaches.

We cannot hope to do much by indirect firing, even if we ventured to hold advanced batteries after the opening of the second parallel, and there may not be a second position suitable; so that in some cases we *must* rely upon guns in the fort, and it would be desirable always to have at our disposal a few guns, not only to flank adjacent works, but to command the intervals. For with works 2,000 yards apart we could not rely upon musketry fire from the works, in case our garrison were weak and we had to evacuate our intermediate lodgments on the position.

And this reserve artillery should not be brought into action until the fire of our batteries should have been silenced or have proved ineffective, and, as a rule, not until the enemy are within 400 or 500 yards of our position. He would then find his advance suddenly checked; he would be unable to push on between the forts and throw up lodgments from which to assail our flanks, so that he would either be forced to assault or undertake distinct operations to silence these concealed batteries; and if these are so traced as to be secured from his distant batteries, he would be forced, at considerable risk, to push forward and arm batteries within 500 or 600 yards of the position.

Now we may dispose of our reserve artillery in two ways: (1) for direct firing from the faces; (2) for flanking fire from the flanks.

(1) For direct fire our guns must be placed either in blindages,

with perhaps blinded embrasures, Moncrieff pits, or in iron cupolas in the keep.

Of these we may at once dismiss Haxo casemates on the faces, as it would be almost impossible to shield the masonry, except by the use of iron; they would also occupy too great an extent of parapet unless we construct a rampart above them for infantry; their height would also render their position conspicuous, and, finally, masonry casemates would involve us in unprofitable expense.

Moncrieff pits, on the other hand, are simple and offer great advantages, as we do not require to shift the gun carriages. The guns would be kept down, and a temporary banquette for infantry constructed, until we open fire; they would not involve any complications in the construction of the parapet, and there would be nothing to mark their position to the enemy. Thus two or three pits might with great advantage be constructed on the face of each work.

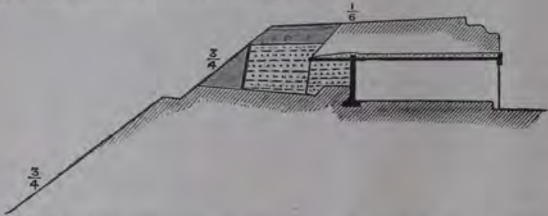
Brialmont has provided several of the Antwerp forts with iron cupolas, but it is evident that they are not adapted to this system of defence. They would offer a good mark to the enemy's artillery at all stages of the attack, and, however strongly constructed, would probably suffer considerably before we required to make use of them. They are employed with advantage by the Dutch engineer in small artillery *forts d'arrêt*, but are scarcely worth their expense on an extended line of forts. However, we should, if possible, have a few guns in the keep for direct firing, and it might be possible to provide the embrasures with movable iron shields.

(2) Next, as to batteries in the flanks; we might place Moncrieff pits on the upper ramparts with, of course, strong parados, if the ground about the forts be of a complicated nature, and we require command for its efficient observation. But, where it is possible, a low battery containing three or four pieces in casemates under the ramparts is preferable. We can then by arrangements of trace and details of construction secure the masonry against direct fire, unless the enemy advances his batteries within dangerous distance from our position.

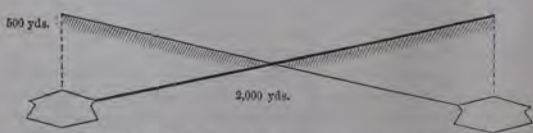
The most convenient position for the battery would be in the advanced part of the flank, adjoining the face, so as to take advantage of the earth covering of the caponier to screen the front of the battery, and of the faces to defilade the casemates opening to the rear. The tracing line of the battery would also be retired as much as possible, so as to form a return in the flank.

As I have not space at present to enter into details of construction, I can only briefly state the system on which I would utilise such low batteries. In the first place, I would limit the line of fire of each gun to 500 or 600 yards from the next fort, as they would not be brought into action until the enemy was within that distance; and each embrasure would provide for its own defence, as we should so trace the outer side as to limit the view of the gun to the desired point. This outer side might be revetted with masonry; the other, or more exposed side, with gabions at a moderate slope.

The masonry at the casemate might be iron shielded, or protected by a short masonry tunnel, forming a section of this nature:



Such a low battery would only answer for a level site, or one on which the forts stand prominently out, as the guns could only have a command of 3 feet 6 inches. The amount of ground under their fire would be this:



Thus a cross fire is brought to bear on the salient of each fort, and on the ground immediately in front of the position; and the enemy cannot assail the front of the battery except at long ranges, or by advancing his batteries to within 500 yards of the adjacent fort.

To conclude this subject I must briefly refer to the use of mortars and field artillery. The former may be most effective defensive weapons, and they have been extensively employed in late wars for the purpose of directing a general fire over the field of siege operations. I should certainly reserve a certain number of mortars within the fort to support the close defence. They might be disposed behind the faces of work or keep, or behind the gorge.

Great use may be made of light field guns and Gatlings, which are capable of being rapidly shifted from point to point. Hollow traverses should be provided on the ramparts for such guns, from which the gun may be run up a ramp, for barbette firing, in case of an assault or sudden attack; or platforms capable of being raised, and with space for a couple of Gatlings, might be disposed at certain points, so that when raised the gun is protected by a bullet-proof shield. We should certainly add to our defences against assault by such devices, as the artillery of the besieger must cease fire when his troops get within a certain distance, and the fire of Gatlings from small bullet-proof cupolas would then be most effective.

Of course this is the merest sketch of the artillery defence on a battery system, and before this could be efficiently organised the mobility of our carriages must be increased, and a practical plan of indirect sighting, with increased accuracy of range finding, must be devised. But, theoretically, there can be no doubt that the plan of massing our artillery in the forts is incorrect, and the Germans have already adopted batteries; but there seem to be defects in their system, and, indeed, exposed batteries are likely to suffer as much as if the guns were in the forts.

With exposed batteries we only gain by the enemy's loss of power of concentration; but we should gain more if we could also decrease the accuracy of his fire on our known positions without materially increasing the inaccuracy of our own fire on his unknown positions.

PAPER IV.

THE SALT LAKE, LARNACA—CYPRUS.

By Lieut. H. M. Sinclair, R.E.

None of the English Expeditionary Force to Cyprus will readily forget the barren and desolate appearance presented by the vicinity of Larnaca on their first arrival. The sun-burnt plain, stretching away for several miles on three sides of the little white minaretted town, and unrelieved by a single patch of green—the white glistening hills behind, equally devoid of vegetation, and standing out with a yellow brightness against the dark blue of sea and sky—form a depressing scene not easily to be forgotten. Beyond the precincts of the town itself, there is no object of interest for walk or ride except one, and that is the Salt Lake. Crossing a low tract, dusty in summer and muddy in winter, to the south of the town, a low range of flat hills is soon reached, and, on emerging from a gap in these, a scene suddenly presents itself of a beauty not to be expected in so desolate a neighbourhood. A large sheet of perfectly still water reflects on its clear and tranquil surface the low brown hillocks which shut it in, the middle distance of yellow and grey, and the blue and purple tints of M. St. Croce and M. Machiera, towering in the distance. The lines of the foreground are broken by the tall minaret and large dome of a mosque picturesquely situated on a promontory in the lake, and surrounded by palms and cypresses, and higher up the arches of the Larnaca aqueduct run in two graceful series. This lake forms the principal object of interest and beauty in the neighbourhood of Larnaca, and, unlike most picturesque places, it supplies to the Government a very large and certain revenue. I propose to give, in the following paper, an account of the lake, and the works, ancient and modern, connected with it.

On my arrival in Cyprus, in October, 1878, I was placed in charge of the Larnaca district for military and civil engineering works, under the command of Lieut.-Col. J. P. Maquay, C.R.E., and Government Engineer. My attention was almost immediately called by the Commissioner of Larnaca, Colonel White, to the state of the Salt Lake, and I made an examination of it as soon as possible. *Pl. I.* gives a map of the lake and neighbourhood, taken from the Naval Chart, the most accurate map of the island, so far as it goes, at present existing. It will be seen that it is an irregular figure about 1½ square miles in extent, but of this area seldom more than one-half is under water. The basin of the lake, though surrounded on three sides by hills about 50 to 100 feet high, rising precipitously from its brink, is almost absolutely flat, and consists of soft, sticky, alluvial mud, with a substratum, a few inches below, of coarse sand. The soil is a very late tertiary formation of conglomerates, sands, and marls. There is no vegetation within the flood-level of the lake. The action of the lake, by which salt is collected, is as follows: In winter, the rains fill it to a greater or less extent, according to the rainfall. About May, the water begins to recede again, owing to evaporation, leaving behind it a deposit of salt. The evaporation continues till July or August, when the whole of the lake has evaporated, leaving a crust of salt, thickening from ¼″ at the edge to 5″ or 6″ in the centre, where the water was deepest and last dried up. At this time it presents a most curious appearance, looking like a large glistening field of newly-fallen snow in the midst of the blazing yellow plain, quivering in the intolerable heat of an August sun. The salt is then collected by large gangs of natives from the neighbouring villages, who proceed in the following way—probably the same that was in vogue in the time of the Phœnicians and Solomon. They begin by scraping up the salt about twenty yards from its edge, as the deposit is at first too thin to be collected with advantage. They pile this into heaps with their rough wooden shovels, working all the time with bare feet in the briny slush that underlies the salt. Care has to be taken that the lowest stratum which is mixed with the mud below is not scraped up. Having worked out about 50 yards, they proceed to construct causeways of the salt itself—to every gang a causeway—upon which they work out to the deeper deposit in the centre, collecting that between the causeways as they go along. The donkeys now come into use, and these most wonderfully hardy and enduring little animals, with big rush-panniers on their backs, convey the salt as it is collected from the lake along the causeways to the shore, where it is piled in great conical mounds, the donkeys struggling up the steep and yielding sides with their heavy load on their backs, and often falling down and rolling in pure salt. Sometimes as many as 1,000 men and 500 or 600 donkeys are employed at once, and the scene is then very picturesque. The numerous causeways of white salt in the black mud, the heaps in the lake and the mounds on its banks, the natives (Greeks and Turks together) in their quaint many-coloured costumes, the lines of laden donkeys, and the great white field in the centre, form a striking and unusual picture. Each gang (of about 25) forms its own mound, and is paid by results, 4*s.* 7*d.* per 1,000 okes (800 okes to the ton). The heaps are weighed, and finally piled into five or six gigantic pyramids, the sides of which are carefully smoothed and beaten. The salt is now ready for exportation, and is left till called for—any rain which falls upon the pyramids running off the hardened surface without injuring it. Last summer (1879) 11,000,000 okes (13,750 tons) were collected, and this (the year being a particularly good one) was not more than one-sixth the quantity available in the lake; but as the Turks, with their usual cunning, have now forbidden the importation of Cyprus salt into Syria and Asia Minor, there is no market for it at present, and the Government judged it unnecessary to collect more. They, however, have circumvented the Turks at their own game, by paying the average income which the latter derived from the lake, £17,360 (4,166,220 okes at 1*d.* per oke), *in salt*, which now lies by the lake ready for H.M. the Sultan's acceptance. The total cost of collection was—10,000,000 okes at 4*s.* 7*d.* per 1,000 = £2,291. 13*s.* 4*d.*, and 1,000,000 at 2*s.* 6*d.* = £125 (as this was beyond the authorised amount and an arrangement was come to with the villagers as to the payment). There was also a sum of £64. 13*s.* 6*d.* for stacking, and the salaries of overseers and guards, which raise the total to £2,630. The present retail price is 1*d.* per oke ($2\frac{3}{4}$ lbs.), the same as it was under Turkish rule, when it was a Government monopoly; but this will probably be reduced if any chance of disposing of it should offer itself, and already 12,000 okes have been sold at 15 paras ($\frac{1}{2}d.$) per oke as an experiment. Its market value in England is said to be 15*s.* per ton, and if recrystallised for table use, 20*s.* or 25*s.* per ton; but this could not be easily done in Cyprus, where fuel is so scarce, unless shallow pans could be constructed near the lake, and the water evaporated in them by the action of the sun. An analysis made by an eminent chemist gives the following result:

Chloride of Sodium	90·024
,, Magnesium	3·380
,, Aluminum	·620
Sulphate of Potassium	1·890
,, Sodium	2·860
,, Calcium	1·070
Nitrate of Potassium	·136
Oxide of Iron	·020
	100·000

His opinion, based upon the result of the analysis, is that the salt is derived from sea water. The first question which arises naturally is, How did the salt get there? and on this point various theories have been advanced, of which M. Gaudry's seemed to be the most plausible. M. Gaudry, a French geologist, who visited the island in 1855–56, and wrote a geological report on Cyprus for the French Government, is of opinion that the high winds in winter force the sea above its ordinary level, and the sea water then percolates through to the lake, where it evaporates. But from careful observations, which I have made in all weathers and all times of the year, I am convinced that his hypothesis is wrong. In the first place, high winds do not raise the mean level of the sea more than about a foot at any time, and it is hardly likely that so small a difference for the short duration of a storm would cause enough water to supply the lake to flow where it did not before; secondly, the level of the lake, even in winter, when it is full, is 5′ *below* the level of the sea, and, therefore, if the sea water flowed at all, it would do so always; and, thirdly, it practically does not flow in, for the lake remained dry the whole summer after it had once evaporated, and only began to fill as the rain fell, and then in exact proportion and at the exact time that the rain did fall, not advancing an inch between the different showers, even though a high east wind was blowing directly on shore. The opinion to which I incline, in spite of M. Gaudry, is that there are beds of rock salt underlying the lake, that the water reaches these beds through the sandy bottom, and becomes impregnated with salt, which would naturally communicate itself to all the water in the lake. This opinion is supported by the fact that rock salt is often found in proximity to gypsum beds, of which there are large masses all round Larnaca, that the water in the wells round Larnaca *above* sea level are brackish, and that I found a piece of rock salt on one occasion on the edge of the lake. I hope that some experiments may be made by boring, to prove the truth of this theory.

Such is the natural process by which salt is produced. But, in order to ensure an annual harvest, artificial measures have from the earliest times been adopted to regulate the supply of fresh water. I have said that the lake at its ordinary winter level is 5′ below the level of the sea, and it is therefore evident that there is no means of getting rid of surplus water, once in the lake, except by evaporation; and should too much be allowed to get into the lake in winter, the whole of it will not be evaporated, and the salt will not be deposited. This was the case in 1878, the year of the English occupation, the previous winter having been an unusually wet one, and the Turks having neglected the ancient artificial works. I had to examine the lake and its surroundings to provide means to guard against a like failure in the future. I found that on each side of the lake there is a canal, formed by an enormous earthen embankment or dyke, starting from the two principal valleys which come down from the hills behind, and, according to native information, bring down floods of water. These canals and embankments (AB and CD, *Pl. I.*) run along the edge of the lake, following the contour in numerous windings and debouch: the one, AB, on the north side of the lake, into the sea near Larnaca, the other into a second lake, south of the Salt Lake, and separated from it by an artificial bund. The embankments must have been constructed at a very early date, for they show every trace of antiquity, are of enormous size and thickness (in some places 20′ high, and of equal thickness at the base); and I found, in working in them, very ancient coins and pottery. I should be disposed to assign them to the time of the Phœnicians, who are known to have worked the lake. The canals are evidently intended to divert the surplus water, coming down from the upper country, from the lake to the sea and the lower marsh. From the very slight fall which they have from start to finish, they require constant care to keep the bed clear and level, and the embankments repaired from the destructive action of sheep and goats passing over them. But this the Turks of course neglected to do, and, the canals becoming choked, the water in flood burst the banks and flowed into the lake, which, up to the time of the English occupation, it continued to do. The canal on the north side was breached at its commencement at A, where it had formerly started under the arches of the aqueduct. I found it would be more convenient to make it start a little higher up, where the valley was narrower and the ground higher. We began repairing the numerous breaches from here downwards, building a core of masonry with earth, well rammed and puddled around and over it. The work had not proceeded far when a heavy fall of rain filled the canal. I went down it to see why the water did not flow off to the sea, and found that, at the point marked E, the bed of the canal rose so that the water could never pass it.

A careful inspection showed that the line of the original canal had been altered, and, instead of passing through the gap at F, had a new channel cut for it through the hill, where the bed rose 5′ *above* the level of the canal behind it. This had been done by an energetic Turkish Pasha, who had put up a monument to commemorate his deed, but who could never have seen the water run down, or rather *up*, his canal, and who probably pocketed the money required to deepen it to the necessary level. Another gang was therefore started to deepen this part of the canal, which, being in a cutting about 15′ deep, was rather an awkward job, with hardly any implements. I adopted the best method which suggested itself, which was to haul the earth up in baskets from the bottom, on slides formed of two planks; two men with pick and shovel below, one hauling up, and one carrying off the baskets to empty. It took two or three baskets to a gang. There was also a bridge, of which the foundations had to be underpinned, as they were 5′ above the required level. There were here about 100 men employed, and the same number at the breaches above-mentioned. They were Greeks, and Turks, and Arabs, white and black mixed, but I invariably found the Turks the best workmen and most trustworthy men. They all worked for 1*s.* per diem, and boys at 6*d.* One lot was superintended by a Frenchman and the other by a Greek, and I had two sappers to keep the checks. Both superintendents received 5*s.* a day. The whole length of the canal, nearly 4 miles, took about three months to put in order.

At the same time that these works were started, I had to report upon a more difficult matter—the canal on the south side of the lake. This was more important, as a constant stream was running into the lake on that side through a breach in the canal at G, being the overflow from the Larnaca aqueduct. This canal runs like the other, along the contour of the steep hill-side. It had to double a promontory in the lake in its course, and at this point its course was obliterated, and it was difficult to discover what had become of it. It soon appeared that the mosque (*Pl. I.* H.) above-mentioned was in the middle of the ancient canal, and the cause of all the difficulty and obstruction.

A visit to the Sheikhs of that establishment—most polite and gentlemanly Turks, with whom I afterwards became great friends—soon cleared up the whole matter. Their story is that Mahommed's wet-nurse, a lady of great sanctity, headed an expedition to Cyprus in her foster-son's interest. But her arms miscarried, and she was killed in battle on the site where the mosque is placed. Afterwards, when in 1570 the Turks took the island, this mosque was raised to her memory, the spot having been miraculously marked by three huge stones brought from Mecca. The stones are certainly there, and exactly resemble a set of those at Stonehenge—two uprights, about 18′ high, 10′ wide, and 3′ thick, with a slab of equal size on the top. They are now enclosed in a dome, with a tomb inside them, and the usual paraphernalia of candles and lamps, &c. I was shown these megaliths as a great favour, and I never heard that anyone had discovered them before me; but I leave the Turks to discuss the authenticity of their legend. The stones, however, are an additional proof of the antiquity of the canal, as they are almost in its centre, and must have been placed there after it was made. In placing the mosque in its obstructive position, the Turks probably intended to show their contempt for the Giaour and all his works. They must afterwards have found out their mistake, for a small tunnel has been carried through the hill behind the mosque, from the canal above it, apparently with the object of remedying the evil; but as, unfortunately, this too, like the canal on the north side, ran uphill, its excellent object was defeated, and the water from the upper country had breached the dyke in several places, and flowed into the lake. The difficulty now was how to get round the mosque. There were three methods available—to enlarge and deepen the Turkish tunnel, to carry the embankment round the mosque, or to make a deep cutting in the hill behind (*See Pl. II*). The first of these would have been a costly operation, as the soil is too soft to stand without masonry, and unsatisfactory, as it was impossible to tell how much water it might be required to take in a flood. The second would also have been very costly, as the ground below the mosque falls immediately to the level of the lake, and an enormous embankment would have had to be formed. There was another objection to this course, viz., that the tombs of the Sheikh's ancestors, held in deep veneration, were on this side, and to touch them would have been sacrilege. The Royal Engineers therefore recommended a cutting through the hill behind, and £1,200 were granted for the purpose. The length of the cutting required was 330 yards, the mean height 25′, and the width at bottom proposed 10′. Colonel Maquay wished to pave and revet with stone, but this expense the Governor would not accede to. These dimensions, with a slope of $\frac{2}{1}$ for the sides, gives 26,160 cubic yards of earth to be removed at rather less than 1*s.* a cubic yard, which, considering that the average wheeling distance was 150 yards, is not an exaggerated estimate. But at a time and in a country where the conditions of labour, soil, and all other data, were almost unknown, it was impossible to make an accurate estimate. Before beginning operations, I urged the Government to procure a light tramway, which I felt sure would be a great saving of expense. But they thought the expense at the time too great, and it was not authorised, so I had to make arrangements for doing the whole excavation by wheelbarrows.

I began with a gang of about 100 natives at each end of the cutting—one under an English foreman named Philipson, who had been with me since I began work on the roads; the other a Frenchman, M. Lehagre, who brought good credentials as an engineer. Each had two native gangers under him. The section of the ground is shown in *Pl. III.* The first 50 yards at either end were easily managed, the cutting being excavated to the bottom, and a ramp left up the side for the wheelers. It was necessary to have a large number of them at the lower (M. Lehagre's) end, as the ground close by was cultivated, and the earth had to be wheeled some 200 yards. As the cutting got deeper the difficulties became greater. Each foreman had a meth which he wished to try, and I allowed them to do so, as the rivalry urged them to do their utmost. Philipson worked out in horizontal layers with ramps up the side of the cutting; Lehagre worked downwards from three points at once, the whole width of the cutting, and when he had reached the bottom worked backwards, throwing up the earth in steps to the top. The former plan in the end proved much the cheapest and quickest. I found it better to employ bullock-carts and wheel the earth at the lower end, as the distance was so great, each cart conveying about a cubic yard a journey, and making 30 journeys a day, the price being 3*s.* 6*d.* a day for two bullocks, a driver and a cart. In this way we reached to within 50 yards of the centre, Lehagre being at the bottom of his cutting, but with a good lump still behind him to come out, Philipson about two-thirds down, and clear behind him. I now found the expense of these methods was getting too great, so I tried a different way, slower but less costly. A bridge had to be provided for communication with the mosque, so I now constructed this, using three 12″ × 12″ timbers 35 feet long, with a roadway of planks across. In the centre of this I placed two sets of pulleys and blocks, supported by a scaffold. The wheelbarrows were filled below, fastened to the fall by a cradle with three hooks for the handles and wheel, and were then hauled up by a pair of bullocks whose yoke was attached to the running end. The barrows were disengaged at the top and run off to be emptied, and then lowered again. This plan succeeded admirably, and we soon cleared out the remaining earth in the cutting. The first 50 yards at each side cost, on an average, 3*d.* per yard all counted; this gradually increased to 6*d.*, when I tried the new method, which again reduced it to about 3½*d.* In the end, when all was finished, I found we had completed the work for £500, less than half the original estimate, and at an average of 4½*d.* per cubic yard. This, when it is remembered that the earth was raised an average of 12½′, and wheeled an average of 150 yards, will appear astonishingly cheap when compared with the cost per cubic yard of such work in England. All tools and material were obtained from the military stores. I was much favoured by the weather, which was almost invariably fine, and the nature of the soil—a stiff clayey marl, which stands very well at a slope of 2 in 1. In one or two places there were layers of shingle, which had to be sloped off to a greater angle, but these were fortunately near the top. The work was begun in the beginning of February and completed by the second week in April.

The extreme cheapness with which the work was accomplished I attribute partly to the energy of my foreman, Philipson, who had trained the gang under him, with the help of two very active Greek gangers, into excellent labourers capable of executing as good a day's work as many an English navvy, and to the wonderful cheapness of labour. The best labourers got 1*s.* a day, inferior men 9*d.*, and boys 6*d.*; mules and donkeys for 3*s.* and 1*s.* 6*d.* respectively; and bullock-carts for 3*s.* 6*d.* were always forthcoming.

I cannot too highly praise the enduring qualities of the Cypriote villagers, their temperate and abstemious habits, and their docility and obedience. I was also much assisted by the kindness of the Sheikhs of the mosque, who were grateful to me for not destroying the tombs of their ancestors (the threat of which I had used as a lever to obtain their consent to the ultimate plan), and who readily sacrificed their land, and to some extent their convenience, to the public service. A few judicious presents, the loan of some wheelbarrows, together with stringent regulations to prevent damage to their fields and property, were amply repaid by their good-will and co-operation.

The canals are now ready for action in case of floods, but as none have yet come down, their utility has not been made apparent. Unfortunately the fall which it is possible to give is so very small, and the soil so porous, that the stream, which it was hoped would flow down to the lower lake, disappears through the ground and soaks into the Salt Lake before reaching that point. Should its action be found to injure the salt crop in summer, after further experience, the bed of the canal will have to be puddled, or the water of the stream diverted higher up for purposes of irrigation.

In conclusion, it may be well to remark that these and other works have been executed under the great disadvantage of a total want of experience, as to the effect of heavy rain in the plains. The most reliable information from various sources has been collected, but hitherto we have been working very much in the dark, and our operations are more based on second-hand reports and theoretical calculation than on practical experience.

H. M. S.

PAPER V.

DEVELOPMENT OF FIELD ARTILLERY.

THE R.A. INSTITUTION PRIZE ESSAYS OF 1879.*

A Criticism.

By Lieut. E. W. Cotter, R.E.

The Gold and Silver Medal Essays of the Royal Artillery Institution contain matter of great interest, not merely for gunners themselves, but for the army generally. The prizemen, as gunners, are naturally apt to take an optimist view of the future of field artillery; it may be, then, not impossible that to look at the matter from an outsider's point of view may lead to a more accurate appreciation of the many points to be considered in deciding on the strength and armament of the field artillery with an army corps.

With our system of voluntary enlistment everything is a question of money. More money will produce more men, more material, more horses. The question to be considered is not whether an increase in any one arm will increase the power of an army, for, of course, every fresh rifle, gun, or sabre will tell; but how, with a given sum of money, the most efficient force for attack or defence can be produced. If there is an increase in the proportion of any one arm of the service, there must be a reduction in the strength of the others. Outside criticism, therefore, on the proposals of each arm, cannot but be of advantage to those who are responsible for the efficiency of the army generally. But the value of outside criticism does not end here; it may be of the utmost value to the particular arm itself. For instance, in the Peninsula, the Duke of Wellington confined the field artillery to 6 horses per gun; the gunners were bent on having 8, and, indeed, so determined was one colonel in his opposition that he was sent home in some sort of disgrace. The question here for the artillery was not merely to get increased mobility by having the higher number of horses, but also whether the advantage gained compensated for the increased

* Gold Medal, Lieut. Goold-Adams; Silver Medal, Capt. Elles.

length of line of march, the increased difficulty of supplying the extra number of horses with the consequent extra number of drivers. This case in the field, where the gunners might say that the particular guns absolutely required the extra horses, is but a miniature of the decisions gunners should make in peace. Their object should be, not purely how to render themselves relatively more important in actual fight, by piling on men and horses, but, taking into consideration cost, length of line of march, carriage of supplies, &c., to render themselves a more efficient element of an army, not only on the field of battle, but throughout a whole campaign. If the artillery become cumbrous, no matter how great the mobility of each carriage, they become detrimental to the efficiency of a force, with a possible result of being left behind, in part, in order not to keep the infantry out of action.*

But it is not only the battery men and horses that have to be considered; weight of ammunition is a very important factor. If a battery has with it 300 rounds per gun, either in its own wagons or with the ammunition columns, an increase of only 1 lb. in the weight of a round means 1,800 lbs. per battery added to the burden of transport. In short, the question is not to get the greatest power per gun in action, but to get that power with the least possible strain on the capabilities of the staff and the supply departments, with the smallest initial cost, and a minimum of men.

Our connection with the gunners is too well known to be here dilated on, whilst, when not technically employed, we are ourselves nothing but infantry; and as by education we are necessarily acquainted with the powers of both arms, it is deemed not too much to say that from no quarter is outside criticism likely to be of more value than from the corps of Engineers.

With this preface let us at once enter into an examination of the proposals of the gallant essayists.

Both prizemen favour the adoption of breech-loaders. Though a few of the reasons they give are open to argument, the balance remains in favour of their proposal; in fact, the matter seems now to have grown beyond argument. The discovery of the advantages of air spacing and chambering, enabling guns to fire much larger charges without increasing the strain, renders long guns to burn the increased charges necessary if the advantages of the discovery are to be realised. It can be easily understood that, though with short guns the breech-loader and the muzzle-loader may be on a par, as the bore lengthens the advantage tells in favour of the former.

* Witness General Roberts's march, in which, despite loss in power, none but mountain guns were taken, though there were horse artillery in Kabul, whence he started.

One advantage not mentioned by the essayists is of importance. To give rotation to an M.L. projectile, the gas-check has been found superior to the stud system, but the gas check, by its own weight and that of its fitments, adds about 5 per cent. to the weight of a projectile, which weight could be very much more usefully employed in the shape of a more powerful shell.* To wit—the experimental 13-pounder (13¼-lb. shell), the greatest triumph of our gun factories, fires a shell weighing about 12½ lbs., the remainder being made up of gas-check and fitments.

It may surprise some to learn that one of the reasons for the adoption of breech-loaders by the French was economy. The Chief of the Artillery Staff in Algeria, in 1876, thus explained to the writer how this conclusion was arrived at: To obtain accuracy with a muzzle-loader the utmost nicety in rifling is necessary, whilst moderately good work in a breech-loader will give better centring, and consequently greater accuracy. Of course more money may be spent by rifling a B.L. gun with delicacy of workmanship; but, if that is done, it is only because the increased accuracy, unattainable in a muzzle-loader, is deemed worth the money.†

Both essayists again agree in recommending increased charges, not only of powder but of projectiles. Capt. Elles merely advocates a long-range 25-pounder, but Lieut. Goold-Adams goes into the matter in detail. The latter proposes to retain our present calibres (3″ and 3″·6) and increase the projectiles from 9 lbs. and 16 lbs. to 15 lbs. and 24 lbs., and at the same time increase the velocities a couple of hundred feet per second, and all this without increasing the draught beyond the powers of 6 and 8 horses respectively.

Draught, or rather the necessity for mobility, is the limiting element of field guns. It is allowed on all hands that horse artillery should not have more than 6 horses, and field batteries not more than 8 horses per gun. The greater the speed the less proportionate value is obtained from an increase in the number of horses, whilst even at low speeds the power of draught does not increase in proportion with the horses. Many have laid down weights that may be drawn by field artillery teams, but all require to be taken *cum grano salis.* The higher the wheel the easier the draught of a given weight; English horses can draw more than continental horses, and, as before pointed

* It is true the gas-check fragments would be useful, but in the shrapnel not so useful as balls placed in front of the bursting charge; whilst in the common shell the weight might be better used in strengthening the walls to prevent prematures and increasing the capacity.

† The writer does not vouch for the correctness of these views; he simply gives them as he heard them stated.

out, the weight per horse will depend on the number in the team. But this is not all; the number of gunners carried is a fresh factor. As a gun team has to move faster and over worse ground in action than on the march, it is the draught in action, which includes the gunners carried on the gun carriage, that limits the weight of material. Wagons will very rarely be brought nearer to the guns than 200 yards in future fights, and, as they are usually heavier than the gun carriages, they will follow the movements of the latter at a slower rate; hence, if a gun is to be efficient, it must have a detachment sufficient to work it, either riding with the piece or carried on the carriage.

From a comparison of a large number of cases (*see* Appendix A), and from deductions and calculations based on height of wheel, I have arranged the following table to suit English horses drawing gun carriages with 5-feet wheels, both heavy and light field batteries to have equal mobility, the weights given to include everything carried behind the teams in action:

	4 Horses		6 Horses		8 Horses		
	Per horse cwt.	Total cwt.	Per horse cwt.	Total cwt.	Per horse cwt.	Total cwt.	
Horse batteries .	$7\frac{1}{2}$	30	$6\frac{1}{4}$	$37\frac{1}{2}$	—	—	*See* Appendix A.
Field batteries .	$8\frac{1}{4}$	33	$7\frac{1}{4}$	$43\frac{1}{2}$	$6\frac{1}{4}$	50	

The Swiss *Aide-Mémoire* for artillery says: 'La force de traction par cheval diminue en raison de l'augmentation du nombre de chevaux, dans la proportion de 8, 7, et 6 pour 4, 6 et 8 chevaux.' Captain Langlois, of the French Artillery, in his work commenting on this, says that these deductions for increased number of horses may be a little exaggerated. As the Swiss have no horse artillery, the statement in the *Aide-Mémoire* must apply to field batteries. The figures above taken, being in the proportion of 8, 7·03, 6·06, are nearer to what Captain Langlois would prefer, and, as they are deduced from practice, they must be very near the mark. The 8-horse draught is $\frac{1}{2}$ cwt. *more* than the 16-pounder, the only field gun which has so large a team. As to the figures given for the 4-horse and 6-horse teams, as against a remark that they are respectively $\frac{1}{2}$ cwt. and $3\frac{1}{2}$ cwt. *less* than the Italian and German equipments,* it may be stated that the writer has seen doubts expressed in an Italian paper to the effect that their light gun would require a larger team, whilst Captain Fraser, R.E., in the United Service Institution Prize Essay for 1879, states that the heavy Turkish gun, exactly similar to the German field gun, was deficient in mobility. The weight for the 6-horse team, as above, is an almost exact mean between the Austrian light and heavy field guns, both of which are drawn by 6 horses.

* The reduced weights, as in Appendix A are here referred to.

Gunners with kits weigh nearer to 13 than to 12 stone; but, as the former are a removable burden, some reduction must be made in making comparisons. Assuming that with his kit the average field gunner is equal to a permanent burden of 12 stone, the following table is arrived at:

		Gunners carried		Remaining for Material	Remarks
		Number	Weight		
			cwts.	cwts.	
H. A.	4 horses	*nil.*	*nil.*	30	In our service 2 N.C.O. and 6 men ride with the piece in the H.A., of whom 3 are horse-holders. In the F.A. 2 N.C.O., one holds the other's horse.
		2	3	27	
	6 horses	*nil.*	*nil.*	37·5	
		2	3	34·5	
F. A.	6 horses	4	6	37·5	
		5	7·5	36	
	8 horses	4	6	44	
		5	7·5	42½	

It would seem that with fewer than six men with the piece there is a loss of efficiency; hence, at least that number should be with the gun in the H.A., whilst in field batteries the more carried on the gun carriage the better; the number of seats which may be provided is, however, limited to five.

From the tables given, it appears that with our present arrangements we may adopt a weight of material of 34·5 cwt. for the light gun, which will admit of two gunners being carried in the H.A., thus with the five riders making up a detachment of seven,* whilst five men may be carried in the F.A. without exceeding the above draught. For the heavy gun, if five gunners be carried, 42½ cwt. is left for material. These are practically the same draughts as those proposed by Lieut. Goold-Adams, who thus arranges the qualities to be obtained:

	Calibre	Gun	Projectile	M.V.	Wt. of Material	Rounds
Lt. Field ...	3″	7 to 8 cwt.	15 lbs.	1,550 f.s.	34 to 35 cwt.	40
Hy. Field...	3″·6	12 „	24 „	1,550 to 1,600 f.s.	42 „	30

The experimental 13-pounder M.L. fires a 13¼-lb. projectile with 3⅜ lbs. of powder, with a velocity of 1,595 f.s., the weight of material, including 36 rounds, being 36·85 cwt. If in that gun the projectile was increased to 15 lbs., the M.V. (by the formula $WV^2 = wv^2$) would be 1,500 f.s., or 50 feet short of the desired velocity. Allowing that the substitution of breech for muzzle loading will admit of

* With four riders only, the detachment would be six, thus saving from the danger in first line—1 gunner, 1 horse holder, and 2 horses. Six is the largest gun detachment used abroad.

increased chambering, that the windage will be absolutely sealed, and also considering the slight increase of energy due to longer projectile, we may allow that not more than $3\frac{1}{4}$ lbs. of powder would, in a gun of same calibre and length of bore, be required to give the shot an M.V. of 1,550 f.s. Admitting that a B.L. gun of 8 cwt. could be made to do this with safety, the question arises: Will a carriage of the same weight bear the increase of recoil of 20 per cent.? If we consider that the 13-pounder carriage, constructed within the last three years, has been made as light as is consistent with strength, the answer seems to be doubtful, even if we follow the essayist's advice, and substitute steel for wrought iron and wood everywhere, except in the wheels. Moreover, 40 15-pounder rounds would weigh $1\frac{1}{4}$ cwt. more than 36 rounds of 13-pounder ammunition. Where is the saving to meet this to come from? From the limber, which has to bear the increased weight? Even then the total would be 1·85 cwt. more than the essayist's higher limit of weight (35 cwt.), which is itself $\frac{1}{2}$ cwt. more than we have deduced. But he further proposes the adoption of the Russian buffer,* which allows the trail brackets on recoil to impart motion to the wheels and axletree by stays, which themselves receive the strain through an indiarubber buffer, the middle of the axletree being allowed to move freely in a slot along the under sides of the brackets. By the adoption of this buffer the essayist claims to be able to lighten the carriage sufficiently. I take exception to his calculations, as he did not take into consideration that, though the buffer eases the blow, it does not allow the brackets to slip away as if they had only their own weight. Nor did he consider in his deductions that the difference between the Russian 4-foot and the British 5-foot wheel causes an increase of weight for the four wheels alone of 3 cwt., not to mention that the axletree for a 5-foot wheel must be longer, and consequently heavier than would be necessary, all other things being equal, for a 4-foot wheel.

The main advantage of the buffer seems to be, to make the shock act more gradually and at better positions in the axletree, and it also might allow the *lower* flanges of the trail brackets to be reduced in section. Russian experiments, moreover, are not reliable, nor has that nation been so successful with its artillery to make us feel sure that something really good has been adopted. The writer believes that buffer carriages† are certain to be adopted, sooner or later, yet he cannot admit that the total draught of the 15-pounder could be reduced to 35 cwt., even should the number of rounds carried be reduced to 36.

* A good description of this carriage is to be found in No. 6, vol. x., *R.A. Institution Proceedings*.

† Not necessarily of the Russian pattern.

But there is another question to solve, viz., Is it advisable to fire 15-lb. projectiles from a gun of 3″ calibre? Professor Greenhill has come to the rescue to enable us to decide this point. By some intricate calculations* he arrived at a formula by which to find the proper rotation for elongated projectiles. The results obtained by this formula are wonderfully good, to wit: two of the most accurate rifles in existence, the 40 c.m. Krupp and the Martini-Henry, the one weighing 72 tons, the other an infantry weapon, should have twists, the former of 1 in 45·753, the latter of 1 in 50·744. The Krupp has 1 in 45, and the famous Henry barrel has 1 in 49.

The following, as regards twists, are deduced from the Professor's results:

	Common Shell			
Twist	Length of Shell in Diameters	Weight for 3″	Weight for 3″·6	Shrapnel. Weight for 3″ gun
1 in 28	4	14·4 lbs.	23·4 lbs.	15 lbs.
1 in 30	3¾	13·5 ,,	22 ,,	14·1 ,,
1 in 32½	3½	12·6 ,, †	20·6 ,,	13·2 ,,
1 in 35½	3¼	11·7 ,,	19·1 ,,	12·2 ,,
1 in 39	3	10·8 ,,	17·6 ,,	11·2 ,,

The weights are obtained by deductions from service shells, allowing for the facts that the clearance of future projectiles, owing to absence of necessity for windage to light the fuze, will be only 1 per cent. of the calibre, instead of, as in our present field guns, 2 per cent. Also that, as the pressures per square inch will, owing to chambering and air spacing, remain nearly constant in both calibres, the walls of the shells of the larger calibre will be relatively thinner, increasing the capacity, but reducing the weight.

From the table it would seem that with a twist of 1 in 30, as in our present field guns (M.L.), a common shell, 13½ lbs., is the limit beyond which, in a 3″ gun, we should not go. If, however, we increase the effect of the shell against entrenchments by packing it with gun cotton at a high density, as proposed by the essayist, the weight might be increased to 14 lbs. without greater length. The advantages of such a course are doubtful, for not only has the use of gun cotton been made the subject of experiment,‡ but, as it gives forth no smoke, it would render common shell useless in ascertaining range; and as, most likely, the walls on explosion would be shivered almost to dust, the man-killing power would be destroyed.

* *See* No. 7, vol. x., *R.A. Institution Proceedings.*

† Without a gas-check the 13-pounder common shell would weigh about this amount. It is almost exactly 3½ diameters.

‡ Except as a small primer in the experimental water shell, which was not adopted. Further experiments with gun cotton as the burster for shell have been made since this paper was written.

If the common shell were made 15 lbs., a twist of 1 in 27 would be necessary. Now increased twist means increased strain, with sharper recoil and greater wear on the grooves, and, with an increasing spiral, loss of velocity. For further examination of this question *see* Appendix C, from which, and from the above, it will be seen that a $13\frac{1}{2}$-lb. shell seems the outside that should be adopted for a 3″ gun.*

A shrapnel of $3\frac{3}{4}$ calibres would weigh 14 lbs., but, surely, having suited an equipment to fire one projectile which is useful as an incendiary and man-killing projectile, useful in ascertaining range and in destroying entrenchments, it would be a very wrong course to increase the weight of everything in order that half the projectiles might have a slight increase in effect; if followed, the two natures of shell would require different range tables, and different lengths of fuze.

If the weight of the projectiles were reduced from 15 lbs. to $13\frac{1}{2}$ lbs., and the charge from $3\frac{1}{4}$ lbs. to that of the 13-pounder, $3\frac{1}{8}$ lbs., then, keeping the gun at 3 cwt., and carrying 36 rounds of ammunition, the draught, by the adoption of a buffer, might be reduced to $34\frac{1}{2}$ cwt.

Similarly, it is found that a 24-lb. shrapnel and a 22-lb. common shell would suit a 3″·6 gun with a 1 in 30 spiral. As the relative value of both projectiles is, in the larger gun, more equal, the case for not increasing the weight of the shrapnel beyond that of the common shell is still stronger. Besides this there is the question: With 24-lb. projectiles, can we obtain the velocity required from a 12-cwt. gun, or from a gun of any weight, without having excessive length of bore? The essayist almost assumed 1,600 f.s., though he allowed a margin from 1,550 to 1,600. When it is considered that a 3″·6 chambered to $4\frac{1}{4}$ inches would require, to realise the higher figure, a bore at least 24 calibres long—that is, 18″ longer than the present 16-pounder—and when we add to this at least 6″ behind the bore due to breech-loading—that is, 2 feet in all—it seems improbable that the same quantity of metal which fires an 18-lb. shrapnel with an M.V. under 1,300 f.s. could fire with safety one weighing 24 lbs. at a velocity of 1,600, weakened as it would be by the breech openings.

The strain on the carriage, if the weight of the gun was kept down to 12 cwt., would be increased, as compared with the 16-pounder, as 8 to 3, whilst 30 rounds of 24-pounder ammunition would weigh 3 cwt. more than the 28 rounds carried by the 16-pounder, as the former would require a charge of 6 lbs. as compared with 3 lbs. Surely all this cannot be made good without increasing the total weight of material beyond 42 cwt. (same as 16-pounder), or $42\frac{1}{2}$ cwt., the limit we have taken. The writer does not believe that any improvement in

* No existing field shell has so great a length.

carriage construction, the adoption of a buffer, or any other contrivance, would enable us to even approximate to this result.

If we are satisfied with a velocity of 1,600 f.s. in the light gun, it would follow that the projectiles of the heavier gun, which, being longer, will retain their velocity better, with the same comparative efficiency may have a less M.V. The German, French, and our present systems are so arranged; indeed, it is difficult to see why a reverse disposition should be adopted. Five lbs. of powder could fire a 22-lb. projectile from a chambered 3″·6 gun with a velocity about 1,500 f.s., if the bore be as long as that of the 13-pounder (23·3 calibres). If 24 rounds were carried in the limber, as at present, we would have, as compared with Lieut. Goold-Adams's proposal, a saving of $2\frac{1}{4}$ cwt. in weight of ammunition, combined with a reduction in strain on the carriage in the proportion of 4 to 3, whilst we feel sure that a 12-cwt. gun could do what is required. To fire against an entrenched enemy, a powerful common shell is required, and as late warfare foreshadows increased use of entrenchments, it is thought that, if the power as above can be obtained, it might be adopted, provided the weight of material be kept down to $42\frac{1}{2}$ cwt. Were it not for this question of entrenchments, the writer is of opinion that it would be better to arm all the field artillery with the lighter gun. Assuming, owing to our increased knowledge of field gun-carriage construction, and to the reduction in *maximum** strain on gun and carriage due to air spacing and chambering, that the weight can be kept down as desired, we can tabulate the modifications of the essayist's proposals, which we think necessary:

		Weight of Material	Shell	M.V.	No. of Rounds
Light Gun	Lt. Goold-Adams	34 to 35 cwt.	15 lbs.	1,550 f.s.	40
	Modified . . .	$34\frac{1}{2}$ „	$13\frac{1}{2}$ „	1,600 „ †	36
Heavy Gun	Lt. Goold-Adams	42 „	24 „	1,600 „	30
	Modified . . .	$42\frac{1}{2}$ „	22 „	1,500 „	24

As regards the details of the carriage, the proposal to abolish axletree boxes is to be commended for their weight, and that of the rounds in them would be removed from the most objectionable position in which they could be placed. A round of case could be carried, as suggested, in leather pockets between the trail brackets, where the weight would rather ease the blow on the axletree, and be not more hurtful to the trail than in the present position. The weight of the boxes, which have to be large to act as seats, would thus be saved.

If we retain wrought iron as the material for the trail brackets,

* As distinguished from *total* strain.

† 1585 by calculation, but a similar allowance for breech-loading and increased chambering as that made for the 15-pounder is taken.

greater strength for the same section may be obtained by pressing down the flanges hot, instead of, as at present, riveting on angle iron, saving at the same time the hurtful weight of the rivet heads. This is deemed better than merely bending over the plates cold, as in Italy and Russia, as, no matter how good the iron, there is a loss of strength at the bend, and, when bent, there is a loss of stiffness, nor is it possible to get the flange equally well placed as if shaped hot.*

And now as to the advisability of adopting pole in lieu of shaft draught, recommended by Capt. Elles. The writer cannot see that there is any doubt in the matter. We are the only nation that adopts shaft draught for gun-carriages, and we stick to them on purely conservative principles.

The solitary advantage of shaft draught is that, with a *powerful* horse in the shafts, the carriage is more under control in turning. Our text-books say that a pole bears down on the horses when crossing a ditch or depression in the ground. Is this true of a gun-carriage? If you have a rigid four-wheeler, as the Royal Engineer pontoon wagon, by all means use shafts, for then they can hinge on the carriage. But a gun-carriage is not a rigid four-wheeler, and hence both shafts and poles are necessarily rigidly connected with the limber, with a result that one bears down pretty well as much as the other, the pole perhaps a little more, because it is longer, but then two horses receive the pressure instead of one.

The disadvantages of shaft as compared with pole draught are as follows:

(1) In stopping or going down hill, one horse, instead of two, bears the weight of the carriage.

(2) The shaft horse alone is always kept up to his work, receiving every jerk from the limber, so much so that, as Captain Elles says, it is common to see the other horses fresh and the shaft horse thoroughly exhausted.

(3) Special harness is required for a shaft horse.

(4) Should the shaft horse fall, it is difficult to extricate him—a difficulty increased tenfold should he be killed.

(5) A shaft limber is heavier than a pole limber, reducing thereby the number of rounds that may be carried; moreover, the weight of the spare shafts carried on the ammunition wagon is greater than the spare pole.

(6) A pole limber has fewer parts, and is cheaper than a shaft limber.

* There is no part of the equipment where steel would show to greater advantage as compared with wrought iron than in the axletree.

(7) Projection of the limber hook to the rear enables a carriage to lock further in turning; it is more difficult to project it with a shaft than with a pole limber.

As an instance of this last, though the extreme length of carriage in the Austrian service is greater than in ours, their carriage can turn in two-thirds the space, thus enabling a battery to occupy less ground. Partly this, no doubt, is due to the fact that the wheels are smaller, but mainly to the fact that the pole projects to the rear, so that the limber hook is as far back as the rear of the wheels, enabling the carriage to lock to an angle of 80°.

Both essayists recommend the adoption of rifled howitzers, but for different purposes. The gold medallist proposes a 32-pounder, drawn by 8 horses, to act as a sort of field siege howitzer for the attack of entrenched positions, provided with blindages and splinter proofs; the silver medallist a light 25-pounder to assist the attack of infantry with vertical fire after the low trajectory weapons have been obliged to cease for fear of hurting their own men. Neither propose to reduce the long-range batteries so as to substitute howitzers without increasing the proportion of artillery. Of course, both the objects mentioned by the essayists are highly desirable; the question merely is: Is it worth while to adopt howitzers at a cost either of reducing the number of long-range batteries, or reducing our cavalry or infantry? for all cannot be provided for the same money, the same number of recruits, the same carriage of supplies, with in either case the disadvantage of increasing the number of different sorts of ammunition carried with an army.

Howitzers in defence would be of little practical use; they would be heavily handicapped in the preliminary artillery fight, whilst, if they came into front line later to fire case, they would simply occupy ground that could much better be occupied by infantry. Moreover, if we increase the common shells of our heavy field guns from 16 to 22 lbs., the necessity for howitzers becomes of less importance. To use a long-range 22-pounder for curved fire is not waste of power, for two reasons: 1st, curved fire strains a carriage more than direct fire, and hence the low charges are necessary; 2nd, when a gun has to cease direct firing, it is better to commence curved fire than not fire at all. The 22-pounder would be a powerful weapon, whether for curved or direct fire, and therefore it is believed to be a far better course to render it capable of quickly changing from one sort of fire to another,* than to adopt howitzers with their many disadvantages.

* An extreme elevation of 25° might be provided, and this would be ample for curved fire, the drop at 1,300 yards being about 1 in 2. The twist (1 in 30) is greater than that of the service siege howitzer of 6"·3, which has 1 in 35.

As to the proportion of artillery in an army corps, let us see what the French and Germans have adopted after their experience:

German Corps, 25,000 bayonets.

Cavalry Division, 1 horse battery	1	Total, 17 batteries, or 4 guns per 1,000 bayonets.
Corps Artillery, 2 horse and 6 field batteries . . .	8	
Divisions, each 4 field batteries	8	

French Corps, 26,000 bayonets.

Cavalry Brigade, 1 horse battery	1	Total 19, or $4\frac{2}{5}$ guns per 1,000 bayonets.
Corps Artillery, 8 field and 2 horse batteries . . .	10	
2 Divisions, each 4 field batteries	8	

British Corps, 21,000 bayonets.

Cavalry Brigade, 1 horse battery	1	Total 15, or $4\frac{2}{7}$ guns per 1,000 bayonets.
Corps Artillery, 3 horse and 2 heavy field batteries . .	5	
3 Divisions, each 2 heavy and 1 light field batteries . .	9	

The British proportion is consequently a mean between those of the two other Powers. If it be true, as stated in our 'Field Exercises,' that the object of field artillery is merely to give the *necessary* support to infantry, it would seem that the more powerful the guns, the fewer of them are required. It remains, therefore, for the artillery to prove that they are really the arm that bears the brunt of the fight before increased power becomes an argument in favour of increasing the proportion of guns in an army.

Seeing how great would be the weight of transport of ammunition for the 22-pounder, considering also that it requires 8 horses, and more space in which to manœuvre, that it would fire less quickly and have fewer rounds with it than the light gun, and that, owing to its larger team, it would be more likely to suffer in mobility by casualties among the horses, the writer proposes to relegate it to the corps artillery, instead of distributing the light and heavy batteries as at present, with a consequent advantage of having all the divisional batteries armed with the same weapon, and enabling the divisional ammunition columns, with same transport, more effectually to supply the batteries.

As the number of light batteries would be thus largely increased, we might increase the number of heavy batteries with the corps artillery, reducing a battery of that expensive corps, the horse artillery, leaving us, however, a larger proportion of it than exists either in France or Germany.* The result, compared with a distribution as at present, is:

	Present			Proposed		
	Horse	Lt. Field	Hy. Field	Horse	Lt. Field	Hy. Field
Cavalry Brigade and Corps Artillery . . .	4	—	2	3	—	3
3 Divisions, each . .	—	1	2	—	3	—

* Italy has no horse artillery. Major Kemmis, R.A., in the Prize Essay of this year, recommends a reduction of the horse artillery batteries to two per army corps —a still larger step.

Such a distribution would result in a saving of 120 battery draught horses and 60 drivers, besides the 36 H.A. riding horses and the reduction that might be effected in spare horses and their drivers. Will any artillery officer deny that this would be an increase in efficiency equal to a very large increase in gun power? It should be remembered that the proposed light guns would be more efficient than existing heavy ones.

In conclusion, let us collect the result of what the writer believes to be an impartial examination of the proposals of the essayists :

(1) A return to breech-loading for field artillery.

(2) That, for a light field gun, suitable for horse artillery as well as field batteries, a power equal to a 13½-lb. shot, fired with an M.V. of 1,600 f.s., is as great as we can hope for. The number of rounds with the gun might be 36, the draught 34½ cwt.

(3) That, for a field gun, due regard being given to mobility, a power equal to 22 lbs., fired with an M.V. of 1,500 f.s., is the utmost that can be obtained, 8 horses being allowed, the draught 42½ cwt.

(4) That, the necessity for rifled howitzers, or for any increase to the present high proportion of field artillery with an army corps, is not proven.

(5) That, for gun carriages and their wagons, pole draught is distinctly superior to shaft draught.

In the meanwhile, our field guns are inferior in power to those of continental nations, whilst the number of men and horses per gun is very much greater—a peculiar anomaly, considering that our difficulty is men, not material.

I append a table (*see* Appendix B) of the field guns adopted by continental nations. Of these it may be remarked that they form the second effort of Germany, Italy, Austria, and England, and the third of France, in the production of rifled field artillery.

E. W. C.

APPENDIX A.

WEIGHTS DRAWN BY FIELD ARTILLERY TEAMS.

Nature of Piece	Gun Carriage, packed complete	Gunners with Gun: Riding, exclusive of Horseholders	Gunners with Gun: Carried with the piece	Gunners with Gun: Weight of Gunners* carried at 12 stone	Total Weight behind Team	Horses in Team	Weight per Horse	Height of Wheels	Reduced Weights† for 5-ft. Wheels: Total cwt.	Reduced Weights† for 5-ft. Wheels: Per horse cwt.
	cwt.	No.	No.	cwt.	cwt.	No.	cwt.	in.		
HORSE ARTILLERY.										
9-pr. gun for India, original . .	34·1	5	2	3	37·1	6	6·18	60	37·1	6·18
9-pr. at present . .	33·9	5	2	3	36·9	6	6·15	60	36·9	6·15
8-cm. Austrian . .	30	3	4	6	33	6	6	54	34·79	5·80
8-cm. German . .	35·2	7	*nil*	*nil*	35·2	6	5·86	55	36·76	6·12
LIGHT FIELD ARTILLERY.										
British 9-pr. of 8 cwt. .	35·9	1	5	7·5	43·4	6	7·23	60	43·4	7·23
Austrian 8-cm. . .	30	1	4	6	36	6	6·00	54	37·95	6·32
Italian 7-cm. . .	24·6	1	4	6	30·6	4	7·65	49·5	33·69	8·42
HEAVY FIELD ARTILLERY.										
Austrian 9-cm. . .	37	1	5	7·5	44·5	6	7·41	54	46·91	7·82
German 9-cm. . .	37·7	1	5	7·5	45·2	6	7·53	55	47·11	7·35
British 16-pr. . .	42	1	5	7·5	49·5	8	6·19	60	49·5	6·19

* Gunners with their kits weigh nearer to 13 than to 12 stone, but some allowance must be made for the fact that they are a removable burden.

† It has been taken that for equal draught the weights may be increased in the proportion of the roots of the heights of the wheels. Except in going up a steep hill, the roads being smooth, this is rather under the mark. The exact calculation for friction at the pipe box gives, that the weights may increase as the cube roots of the squares of the heights, whilst the power of overcoming obstacles gives increases in still greater proportion.

APPENDIX B.

PRESENT FIELD ARTILLERY OF FRANCE, ITALY, AUSTRIA, GERMANY, AND BRITAIN.

Nature of Gun		Calibre	Gun	Horses	Gunners carried	Weight behind Team: Material only	Weight behind Team: With Gunners carried	Weight behind Team: Per Horse, total	Common Shell	Shrapnel	M.V. of Common Shell	Rounds with Gun	Powder Charge
		in.	cwt.	No.	No.	cwt.	cwt.	cwt.	lbs.	lbs	f.s.	No.	lbs.
France . B.L.	Light .	3·15	8·46	6	..	..	..	..	13·2	..	1,608	30	3·3
	Heavy .	3·5	10·43	6	..	..	..	..	17·6	..	1,492	24	4·2
Italy . B.L.	Lt. Field	2·95	5·8	4	4	24·6	30·6	7·65	8·2	9·37	1,312	48	1·21
	Hy. Field	3·43	9·6	6	..	..	..	..	about 16	..	1,490	..	about 3·3
Austria B.L.	Horse .	2·95	5·9	6	2	30	33	5·5	9·5	10·3	1,397	40	2·09
	Lt. Field	2·95	5·9	6	4	30	36	6·00	9·5	10·3	1,397	40	2·09
	Hy. Field	3·43	9·6	6	5	37	44·5	7·41	16·1	15·55	1,480	34	3·3
Germany B.L.	Horse .	3·09	7·7	6	*nil*	35·2	35·2	5·86	11·15	12·17	1,525	40	2·75
	Field .	3·46	9	6	5	37·7	45·2	7·53	15·4	17·43	1,456	34	3·3
Britain . M.L.	Horse .	3	6	6	2	33·9	36·9	6·15	9·06	9·8	1,391	40	1·75
	Lt. Field	3	8	6	5	35·9	43·4	7·23	9·06	9·8	1,381	40	1·75
	Hy. Field	3·6	12	8	5	42	49·5	6·19	16·19	17·9	1,355	28	3
Experimental M.L. 13-pr. . .		3	8	6	..	36·85	..	..	13·25	13·25	1,595	36	3·125

The details of the new French equipment, as above, have not yet been published. The Light gun is for both Horse and Light Field Batteries.

The details of the Italian Heavy gun are not known. Italy has no Horse Artillery.

The German Light gun is for Horse Artillery only.

With mark I. carriages, now used only with Field Batteries, the weights of the British Light and Heavy gun carriages would be 1 cwt. and ½ cwt. respectively more than the above weights, which are those of present pattern.

APPENDIX C.

Comparison of 15-lb. with $12\frac{1}{2}$-lb. Projectiles in a Light Field Gun.

Light Artillery does not pepper away at long ranges; its duties are to support the other arms with its fire, advancing with them in attack to the distance whence its fire will produce the utmost effect, sacrificing itself, if necessary, and in defence remaining in position with the hope that the last round of case might cause an attack to fail. The ranges it will most affect may therefore be considered to vary between 800 and 1,800 yards. It will avoid in attack shorter ranges, as the loss due to the enemy's infantry fire would be so great that the effect would be reduced. Let us then take a mean range, say 1,200 yards, and compare the relative advantages of a $13\frac{1}{2}$-lb. and a 15-lb. shell at that distance.

Suppose an equipment suited to Light Artillery, everything fixed except the nature of ammunition. Let the gun have a 3-inch calibre of such a length and such a chambering that with 3 lbs. of powder the $13\frac{1}{2}$-lb. shot will have an M.V. of 1,600 f.s., and the carriage sufficiently strong to just withstand the recoil due to this momentum efficiently. If we increase the weight of the shot, we must, to have same recoil, reduce the charge; in other words, the momentum of the projectiles at the muzzle must be equal—that is to say, the following amount for each gun must be equal—(shot + $\frac{1}{2}$ charge) × velocity—.

At least 2 lb. 10 oz. would be required to give the 15-lb. shot the momentum of the $13\frac{1}{2}$-lb. shot as above, say only 2·6 lbs. We then have $(13\frac{1}{2} + 1\frac{1}{2})\ 1{,}600 = (15 + 1{\cdot}3)$ × velocity of 15-lb. shell, whence we find velocity of 15-lb. shell equals 1,473 f.s. The generally accepted measure of the value of a projectile is its energy, all other things being equal. At the muzzle the $13\frac{1}{2}$ lb. shot will have the advantage, but it will not retain it. At 1,200 yards the velocities would be: Of $13\frac{1}{2}$-pounder, 1,144 f.s.; of 15-pounder, 1,099 f.s.; the energies being in the proportion of 1,766 to 1,812, or an advantage of only 2·6 per cent. in favour of 15-pounder. Does this balance an increase of 6·6 per cent. in the weight of a round, not to mention the loss in speed of firing, and the other disadvantages noted in the text? Besides, beyond a certain length the bullet or powder capacity of a shell will not increase in proportion to weight. The answer seems decidedly in favour of the light projectile.

PAPER VI.

BOUNDARY LINE

BETWEEN THE

ORANGE FREE STATE & GRIQUA-LAND WEST.

BY BREVET LIEUT.-COLONEL CHARLES WARREN, C.M.G., R.E.

The following observations have been written for the purpose of supplying information to brother officers on subjects which are not fully mentioned in works on surveying, and more especially to show the accurate results which may be obtained with instruments in ordinary use.

IT will not be necessary to give in detail any account of the political complications which led to the laying down of the Boundary Line between the Orange Free State and Griqua-Land West, beyond stating the broad facts that the Diamond Fields were claimed by Chief Waterboer of the Griquas, and by President Brand, Orange Free State: that the British Government acquired the rights of Waterboer, and that after some protracted negotiations it was arranged that the Orange Free State should abandon its claim on receiving from Griqua-Land West the sum of £90,000.

On 13th July 1876, a Memorandum of Agreement regarding the Boundary Line, was drawn up between Earl Carnarvon, Secretary of State, and His Honour President Brand, Orange Free State, as follows:—

1. The frontier shall be known and recognised hereafter (subject to the provisions in para. No. 2) by a line drawn from Ramah (Fountain) passing through David's Graf (close above the junction of the Reit and Modder Rivers) to the beacons standing on

Tarantaal Kop (and marked by De Villiers on the map referred to hereafter), thence by a straight line at right angles to the line from David's Graf to the summit of Platberg, and from the point where the two lines join, hence to the summit of Platberg, thence in a straight line to the point marked G on the said map, on the River Vaal, including the whole of the places known as the Diamond Fields.

2. The boundary line given shall be drawn so as to leave within the Free State territory the farm belonging to Gideon Joubert, and the four farms occupied by Commandant Dolf Erasmus, according to the boundaries of the said farms as registered in the Registry of Deeds Office of Bloemfontein, on the 27th October, 1871, but verified and certified by examination, and by marking of beacons, to be made on the spot by two experts, approved by the Right Hon. Earl of Carnarvon, and his Honour President Brand.

3. The map now in the hands of the Earl of Carnarvon, drawn by M. Jos. de Villiers of the Free State, and signed in duplicate, shows the boundary as herein set forth. But it is admitted that this map is to be verified and approved on the spot by the experts herein referred to, who will make out the line of boundary by beacons, and make out two copies of the chart, and sign the same, which is to be completed within six months, unless prevented by unforeseen circumstances, or sooner if possible.

Paragraphs 4 and 5 do not refer to the survey.

3rd October, 1876, Colonial Office to War Office, referring to permission having been granted for Captain C. Warren, R.E., to conduct Survey of boundary line, requests that he may be directed to place himself in communication with Colonial Office without delay.

6th October, 1876, Captain Warren sends a preliminary report on "Tracing of Boundary Line."

No. 24.

Captain Warren, R.E., to Colonial Office.

SIR, *Waltham Abbey, October 6th* 1876.

I have the honour to transmit herewith a preliminary report on the subject of the tracing of boundary line between Griqua-Land West and Orange Free State.

I have, &c.

(Signed) CHARLES WARREN, *Captain, R.E.*

Griqua-Land West and Orange Free State.—Tracing of Boundary Line.

The work to be performed appears to be as follows:—

1. To fix accurately on a plan, either by astronomical observations or trigonometrically (with reference to the Observatory of Cape Town), the positions of Kimberley, Ramah, David's Graf, Tarantaal Kop, Platberg, point G on River Vaal, and about six other points on the boundary line.

2. To survey and delineate on plan, accurately, the eastern limit of the Diamond Fields, which have to be included in British territory, and also the western limits of the four farms occupied by Commandant Dolf Erasmus and the farm belonging to Gideon Joubert, which have to be excluded from British territory.

3. To trace out, chain and beacon, the boundary line over an extent of upwards of 120 miles, showing the general features within a mile on British side of the line.

This line is not necessarily a series of straight lines, as sketched on map; it may possibly be found to run in a most irregular course, in order to include the Diamond Fields and to exclude the farms above-mentioned.

For the work in hand there are no materials at present available. The map can only be used for the purpose of indicating the direction of the line; it is on too small a scale and of too rough and uncertain a description to be of any use, either in assisting, or in forming a basis for, the correct delineation of the boundary line.

The question then arises, what is the best method of performing the work in hand?

As a standard of comparison I may mention that the 120 miles of boundary, if traced and laid down with the same accuracy and on the same scale as was required on the North American Boundary Survey, would cost 29,000*l.*, and would occupy four Officers and forty-five Non-Commissioned Officers and Sappers nine months. On that occasion a belt of six miles breadth on the British side was surveyed trigonometrically.

On the present occasion so great an expense cannot be incurred, but yet it would not be desirable to limit the accuracy and durability of the work too far by the curtailments of the expenditure.

Assuming, however, that the very cheapest form of trace be adopted, compatible with accuracy, I note the work which yet appears to be absolutely necessary.

(*a.*) Examination of the plans of the five farms registered at Bloemfontein, and the determination of their western limits on the ground.

(*b.*) Examination and verification of the eastern limits of the Diamond Fields on the ground.

(*c.*) Examination and verification of the point of departure at Ramah, the points at David's Graf, Platberg, &c.

(*d.*) A series of observations at Kimberley, to ascertain its longitude from Cape Town by the electric telegraph; and latitude astronomically.

(*e.*) Observations for latitude and time, and longitude by chronometers, from ten or twelve stations on the boundary line.

(*f.*) The laying out the boundary line.

(*g.*) The chaining of the line, and survey of one mile on British side.

(*h.*) Erection of beacons.

(*i.*) Computation of several hundred astronomical observations, and plotting work on plan.

(*j.*) Special survey of Kimberley.

(*k.*) Barometric observations for heights.

(*l.*) Special survey of any places to be connected with the boundary line.

(*m.*) Connection of any conspicuous points within thirty miles on British side of boundary line.

(*n.*) Completion of survey on scale of four inches to the mile, and of general plan half-inch to the mile.

I have to propose that, as is usual on such a service, the boundary line be chained throughout its length, and that beacons be erected at intervals of one mile in populated districts, and in any diamondiferous soil; and at three miles in wild portions of the country.

The cairns should be of so large and compact a nature that they may not be gradually overturned and obliterated by wild animals.

The estimate which I have formed, and which is necessarily most approximate, is as follows :—

	Per Annum.	
	£	£
Salary, Captain Warren	600	
,, four N.-C. Officers, R.E. ...	370	
Outfit, Captain Warren (to include horse)	70	
,, four N.-C. Officers	60	
Passages	110	
	——	1,210 from England
Two chain-men from Colony ...	350	
Rations and lodging...	600	
Two horses for party	90	
Native workmen, carts, erecting cairns, travelling expenses ...	2,750	
	——	3,790 from Colony.
Total		£5,000

Although I do not think it would be a very desirable alternative I submit another scheme, by which the chaining of the line may be omitted and the distances obtained in another and less rigidly accurate manner.

	Per Annum.	
	£	£
Captain Warren	600	
Two N.-C. Officers, R.E.	230	
Outfit, Captain Warren (to include horse)	70	
,, N.-C. Officers	30	
Passages	70	
	——	1,000 from England.
Rations and lodging...	380	
Two horses for party	90	
Natives, carts, erecting beacons ...	2,530	
	——	3,000 from Colony.
Total		£4,000

I beg to point out that the great expense will be in the Colonial and native labour.

The wages appear to be—	s.	d.	
Artificer	20	0	per diem.
Ground labourer...	7	0	"
Coolie	2	6	"

As none of these men would in any way be trained to the work and would probably be adventurers, it appears clear that it would be far more economical to take three or four Non-Commissioned Officers of the Engineers, who would do double the work in comparison with any assistants obtainable in the Colony at half the pay.

The difficulty of employing civilians (who are not specially trained) on surveying in a wild country is well recognized. The American surveying party on the eastern side of the Jordan entirely collapsed on this account.

With regard to the cost of erecting beacons, &c., I have made a rough approximation, but I do not think it is in excess.

I have not included the cost of instruments in the estimate because I am under the impression that the greater number of them may be lent by the Foreign Office, or the Admiralty. About 70*l*., however, at least would be required for new instruments, &c.

The work could probably be executed in less than twelve months.

(Signed) CHARLES WARREN, *Captain, R.E.*

London, October 6, 1876.

No. 26.

Colonial Office to Captain Warren, R.E.

SIR, *Downing Street, October* 13, 1876.

I am directed by the Earl of Carnarvon to acknowledge the receipt of your letter of the 6th instant* on the subject of the tracing of the boundary line between the Province of Griqua-Land West and the Orange Free State, in which you point out the nature of the work, which in your opinion should be undertaken, and indicate two different methods by which it may be accomplished. You have also furnished approximate estimates of the cost of these two methods amounting respectively to 5,000*l*. and 4,000*l*., and you observe that you do not consider the method represented by the lower of these two estimates a very desirable alternative.

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* No. 24.

2. Referring first to this latter portion of your report, I am to observe that Lord Carnarvon, while fully recognizing that the estimates are extremely moderate, looking as well to the amount of work which it is proposed to undertake as to the guarantee for its proper execution which is given by your high reputation as a surveyor, is compelled to limit the sum to be expended on this service to the minimum consistent with an effective carrying out of the terms of the agreement with President Brand, of which you have already received a copy. But, inasmuch as the question of expenditure is governed entirely by that of the degree of accuracy required, it may be convenient, in order to decide whether some reduction may not be made in the cost of the survey, to define in general terms the objects which Lord Carnarvon considers it desirable that you should more especially bear in mind in the discharge of the duty entrusted to you, and which will govern to a great extent the amount and character of the work to be performed.

3. Your first duty will be to inspect the line of proposed frontier in conjunction with Mr. de Villiers, the expert nominated by the Orange Free State, and to settle with him what are to be the recognised positions, on the grounds of the points named in the Memorandum of Agreement; this part of the work will involve a verification of the eastern boundaries of the Diamond Fields and of the western boundaries of the farms named in the second clause of the Agreement, and I am to observe that Lord Carnarvon attaches quite as much importance to arriving at a settlement, which on these matters of detail shall be final and satisfactory to both sides, as to the actual precision of the survey work. Adhering therefore to the general spirit of the Agreement, you may consider yourself at liberty, without sacrificing material points, to make such concessions in minor matters as you may consider fair and expedient and as may seem necessary in order to prevent disagreement or controversy in the future.

4. Having arrived at an understanding with Mr. de Villiers on these questions, it will next be necessary to mark by beacons the points named in the Agreement, and a sufficient number of intermediate points to enable the boundaries agreed upon to be verified hereafter: a record of the position of the more important of these beacons in the form of a plan seems necessary, and also probably a survey of the portion of the boundary near the Diamond Fields and the specified farms. But, bearing in mind that all the boundaries

in South Africa have been at the best only approximately defined, and that much of the country is unoccupied and wild, it would seem unnecessary to survey the entire length of the line, or to do more than fix the positions of a limited number of points on those portions of the line which are at present of only secondary importance. For instance, it would hardly appear to be necessary to place any beacons at all on the line between Ramah and David's Graf, provided the points themselves were relatively determined.

5. Such being, so far as Lord Carnarvon is in a position to form an opinion, the objects of the survey, it appears to his Lordship that the second and less rigidly accurate method proposed by you will fully meet all the requirements of the case, and that the estimate of 4,000*l*. will admit of considerable reduction, partly by omitting from the work the items *j*, *l*, and *m* detailed at page 3 of your report, and partly by revising the item of 2,530*l*. for native labour and beaconing; a portion of the cost (at least half) of this service would be chargeable to the Orange Free State, and by reducing the number of beacons and taking advantage of the facilities which the Administrator may be able to give you in providing labour, it would seem possible to substitute a much smaller sum. Moreover it seems to his Lordship very essential that the work should be completed within, at the outside, six months from your arrival in the Province, and the estimate will be susceptible of some further reduction on this account also. On the other hand, Lord Carnarvon observes that you have estimated your own salary at the rate of 600*l*. a year, but, looking to the cost of living in the Province, his Lordship proposes to make an addition to the estimate under this head: and again, as regards the employment of the two Non-Commissioned Officers of Royal Engineers, which his Lordship considers to be necessary, it would seem better to give them a subsistence allowance rather than to undertake to provide them with rations (and quarters when not in the field). The estimate, subject to the revisions, will become:—

Captain Warren's salary for six months	£500
Ditto, half-salary during two months on passage	84
Two Non-Commissioned Officers' pay for eight months ...	154
Outfits for party	100
Passages	140
	978

Travelling expenses of Captain Warren, four months at 2*l*. 2*s*. a-day	£200
Subsistence to two Non-Commissioned Officers at 10*s*. a-day for six months	183
Instruments	60
Horses, carts, &c....	300
Half-cost of beaconing	500
Total	£2,225

(Say 2,500*l*.)

6. In conclusion, I am to request that you will state at your early convenience whether you consider that you can properly undertake the service with a reasonable hope of executing it on these terms, and if so on what date you will be prepared to sail. Your departure should, if possible, take place before the end of this month.

I have, &c.

(Signed) W. R. MALCOLM.

No. 27.

Captain Warren, R.E., to Colonial Office.

SIR, *Waltham Abbey, October* 14, 1876.

I have the honour to acknowledge the receipt of your letter of the 13th instant,* conveying instructions from the Earl of Carnarvon, concerning the tracing of the boundary line between the Province of Griqua-Land West and the Orange Free State.

1. The importance of arriving at a just settlement (satisfactory to both sides) of the details of the boundary, so as to prevent disagreement or controversy in the future, will be a guiding line in the performance of my duties.

2. Taking into consideration the work to be performed on the survey as now limited, the revision of the item for beaconing, and by taking advantage of the facilities the Administrator may be enabled to afford, I have no doubt but that the work can be efficiently performed at a cost within the revised estimate of 2,500*l*., and that it can be completed within six months of the time of arrival in the province.

3. I am prepared to sail at any time after the 22nd instant. I have to suggest that the two Non-Commissioned Officers of the Royal Engineers should embark in the same steamer with me, so that we

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* No. 26.

may be enabled, on passage out, to test the astronomical instruments, to rate the chronometers, and get ready our field-books, and to make such other preparations as will allow of our commencing work on arrival in the Province.

4. I have to submit that, as the expedition of the service will in some measure depend on accurate simultaneous observations at different points, and on the efficiency of my assistants, it would be conducive to economy that one Non-Commissioned Officer should be an expert observer (if possible either from the Ordnance Survey or from the recent North American Boundary Survey,) and that the other should be a good clerk and computer.

5. I have to suggest that six pocket chronometers may be obtained from the Admiralty (Greenwich Observatory), on the same terms as were those obtained for the North American Boundary Survey, namely, that they will be returned in as fair a state of repair as they are issued.

In conclusion, I beg to express my sense of the liberal rate at which Lord Carnarvon has fixed my own salary, on account of the cost of living in the Province.

I have, &c.

(Signed) CHARLES WARREN,

Captain, R.E.

On the 20th November, 1876, I landed at Cape Town with my party (consisting of one Serjeant and one Lance-Corporal, R.E.), and after an interview with His Excellency Sir Henry Barkly, G.C.M.G., proceeded to Port Elizabeth by steamer, having previously sent the Non-Commissioned Officers, instruments and stores, by mule wagon over the Karoo to Kimberley.

From Port Elizabeth I proceeded (28th November) by coach to Kimberley, by Graham's Town and Cradock, a route which passes through the richest sheep veldt.

I was principally struck with the exceeding desert appearance of the country, and the lowering aspect of all the Kaffirs and Hottentots we met. I saw not one happy expression on the face of a native until after crossing the Orange River, and arriving within the limits of the Orange Free State.

Arriving at Kimberley on the 4th December, I was introduced by His Excellency Major Lanyon, the Administrator, to my colleague, Mr. Joseph E. de Villiers, Government Surveyor, who had come over from Boshof to meet me. I started with him for Bloemfontein next day, and was there introduced to His Honour President Brand, Orange Free State, and ascertained from him his views concerning the details of the boundary line about to be laid down.

On my return to Kimberley I went down along the boundary line as far as Ramah on the Orange River with Mr. Orpen the Surveyor General, Mr. de Villiers being employed at the time in the Volksraad at Bloemfontein. I was particularly anxious to proceed over this line with Mr. Orpen, because he had strenuously opposed the views of President Brand regarding the encroachment of the Orange Free State; and as I was about to be colleagued with Mr. de Villiers for so many months, I considered it desirable that I should be fully aware of his views which had been supported by the Governor of the Cape Colony, and the British Government.

On inspection of the ground it was evident to me that with the cordial co-operation of Mr. de Villiers, there would be no insurmountable difficulty in rapidly settling the disputed point.

I returned to Kimberley the 19th December, and found that the two Non-Commissioned Officers with the instruments and stores had arrived the same day. Owing to the exertions of Mr. Orpen and his subordinates, we were enabled to go into camp on the 21st December, outside Kimberley, where I was joined shortly by Mr. de Villiers.

Our camp fittings consisted of one wagon with twelve oxen, leader and driver, three riding horses, a light cart, two tents, two coloured servants, bedding, cooking utensils, &c. We here remained encamped until the 17th January, 1877, during which time, the base of verification was measured, observations were taken to points within a day's journey, latitude and longitude and meridian observations were obtained, and the general scheme for the laying down of the boundary line was elaborated.

It was evident from the nature of the country over which the line would pass (involving the cutting of farms with accurately defined lines) that an astronomical survey or reconnaissance would not meet the requirements of the case, that an accurate triangulation would be necessary.

There already existed a triangulation somewhat to the west of of our line, made by Mr. Orpen, by aid of which the former boundary line was laid down, the calculations concerning which Mr. Orpen most kindly placed in my hands. But in this matter a question at once arose, whether we could with justice to the Orange Free State use the work of a Griqua-Land West antagonist, upon the very line which had been in dispute. This was a subject which required some delicate handling, but eventually it was clearly demonstrated that the value of the survey work of the Surveyor General, could not be invalidated by any conclusions (adverse to the interest of the Orange Free State) which he might derive therefrom, and as a Surveyor, Mr. de Villiers cheerfully acknowledged the worth of Mr. Orpen's survey, although he was strongly opposed to his deductions therefrom.

This was the first difficulty I had to remove, and it was I considered a matter of considerable importance, because it appeared to me that we were bound, from an economical point of view alone, to make use of any existing information, which we might ascertain to be correct, whatever might have been the conclusions derived from it in other hands; and moreover, that it was essential for the consistency of the future maps of the country, that the triangulation which we should carry out (which may possibly be the basis of a trigonometrical survey of the Orange Free State) should be connected systematically with that of Griqua-Land West. This was finally agreed to by my colleague, and it was then arranged that we should carry out an independent series of triangles (from Ramah on the Orange River to Platberg on the Vaal River) to the east of, but throughout its length, systematically connected with, the triangulation of Griqua-Land West; that we should re-measure and use the base line of Mr. Orpen's triangulation (at Kimberley) as our base of verification, and that we should measure a somewhat longer base in a better position at Fredericksfontein, about twelve miles north-east of Ramah.

This was ultimately accomplished, and it was found that the two triangulations, subjected thus to the severest of tests, agreed so closely in every respect, that they could be treated as one triangulation.

A full description is given in the Appendix of the following work which took place here and elsewhere.

(*a.*) Details of the measurements of the Fredericksfontein base, and base of verification. The comparison of the standards of measurement one with another, and results of measurements with deal rods.

(*b.*) Method of obtaining true azimuthal bearing of base of verification and comparisons with the same obtained at the Fredericksfontein base, and calculations for convergency of meridians.

(*c.*) Observations and calculations for latitude and longitude.

(*d.*) Observations and calculations for the triangulation.

(*e.*) Positions of trigonometrical points, obtained by general geometry.

(*f.*) Method of obtaining by calculations the direction of the boundary line, tracing the same, and method of obtaining the right angle on the ground.

(*g.*) Piles at trigonometrical stations, and piles on base line and heights.

(*h.*) Fixing of Ramah, David's Graf and Platberg.

I will now proceed to give some description of the country along the boundary line.

Griqua-Land West is bounded on the south by the Orange River, and is intersected by the Vaal River, which enters the Province at its north-east extremity, and joins the Orange River about the centre of the southern boundary line; the eastern boundary line of Griqua-Land (which was now to be laid down) lies between the Vaal River and the Orange River, at an angle of about 26° to east of true north, the total length being about 120 miles. This country, thus cut off between the Orange and Vaal Rivers, is again intersected about 50 miles from the Orange River by the Riet and Modder Rivers, which effect a junction just within the boundary and flow westward into the Vaal River.

This district was in 1867 an extensive dry sheep walk, favoured with few fountains and little rain, the herbage being in some parts scanty tufts of grass and in others shrubs, supporting about one farm house or tent to 12,000 acres: it was called the Panneveldt.

In 1870 it was discovered that the diamonds which had hitherto been found in the bed of the Vaal River only, were likewise to be found in some of the Pans, which are apparently the craters of extinct volcanoes: and the dry diggings of New Rush (Kimberley), Du Beers, Datoits Pan, and Bultfontein were opened up, and townships established. Water was found by digging wells at depths of from 20 to 100 feet, and the population of these diggings rapidly increased to upwards of 20,000 persons, white and black.

The subject of these diggings I treat of in another paper. This tract of country is elevated about 4,000 feet above the level of the Atlantic, and consists of a series of extensive flats raised one above another, with scarps breaking down from the higher to the lower.

The rocks of this district are principally clays, schists, and limestones, arranged in horizontal strata, and in many instances they are pierced by pipes and dykes of trap, which has intruded itself between the strata.

The effect of denudation has been to remove the softer rocks for a depth of 300 to 400 feet at least, leaving standing portions where the trap has intruded, forming those series of flat topped hills so characteristic of South African scenery, and which are almost invariably surmounted by layers of trap or felspathic rocks.

The action of denudation gives rise to a singular optical illusion. The plains between the ranges of trap-topped hills dip gently to the centre, so that when the eye surveys one of these ranges at a distance over the surface of the plain, the gentle rise towards it gives the effect of distance: thus ranges only 200 to 300 feet in height and distant ten or fifteen miles, look like lofty mountain chains at great distances; this illusion takes away from the exceeding flat appearance which would otherwise characterise the Panneveldt.

The eastern boundary is not a straight line, but a series of right lines; the following is briefly a description.

Ramah, near the Orange River, David's Graf, on the Riet River, and Platberg, near the Vaal River, are nearly in a straight line, while Tarantaal Kop lies about seven miles out of the line to east of and opposite Kimberley.

The boundary line runs from the Vaal River through Platberg Δ in the direction of David's Graf (about 70 miles) until it is cut by a line striking it at right angles from Tarantaal Kop. Thence from Tarantaal Kop to David's Graf in a straight line, and from David's Graf to the Orange River through Ramah in a straight line.

In the line from Platberg towards David's Graf are the two farms of Gideon Joubert and Adolf Erasmus which, by the agreement, had to be cut into the Orange Free State, and along the western borders of which the boundary line had to be traced.

The general line of the country was as follows; a gentle rise for twelve miles, from the Vaal River up to the summit of Platberg, thence over a series of plains and gentle rises until opposite Tarantaal Kop. From Tarantaal Kop a dip and then a rise, a pass at Scholtz's farm, and thence a fall to David's Graf.

A rise from David's Graf to a series of undulations on the Panneveldt, whence no length of observation could be obtained, down to Ramah on the Orange River.

The longest line to be traced was that from Platberg to David's Graf which passed between Kimberley and Dutoits Pan, and exceeded 60 miles in length.

Climate.—This elevated plateau in latitude 28° 30′S. is subject to extremes of temperature. During the winter time there is little or no rain, and a continually cloudless sky; at nights the temperature is below freezing point with icy cold winds, while in the middle of the day it is often extremely hot.

In summer time, the sky is often cloudy; there are frequently thunder storms each afternoon about 3 p.m., and there is a constant change from excessive dryness to humidity in the atmosphere. The whole average rainfall however does not generally exceed twelve inches per annum.

The dry winds, which so constantly blow from the west and north, are so wanting in moisture that well seasoned articles made of English wood are quickly warped and shrivelled up. Despatch boxes and desks which I had used for many years in a variety of climates became so warped that they refused to open or shut, and the electricity of the atmosphere, was so great that when undoing the blankets in the evening there were often bright flashes and a succession of reports.

During the day time in summer, the mean solar radiation vacuum thermometer registered as high as 180° F., and the temperature in the shade remained at upwards of 100° F. for several hours.

In the wagon the thermometer (F.) often stood at 108° for several hours, and under the wagon at 104°. It was found impossible to keep up the attention in calculating when the thermometer was at this height and the atmosphere highly charged with electricity, for it was found that the calculators frequently put down a figure a second time, and thus vitiated the work: in order to avoid this difficulty, the calculations which were done in the field, were for the most part performed at night.

During the intense heat of the day, there would frequently be an icy cold wind for a few seconds, which was quite as refreshing as a plunge into a cold bath.

The thunder storms during the summer were often terrific, the lightning playing all around the encampment, or party, and the ground being struck in all directions. On this account an empty soda-water bottle was fixed on the extremity of each tent pole, as a non-conductor.

During part of the summer, mosquitoes were very prevalent and venomous, especially near the river banks; flies abounded to such an extent that they swarmed round the heads of the observers, and collected in clouds in the tents, and filled and put out the candles. There were no scorpions seen, though they had abounded in previous years, but there were cobras and other venomous snakes in most parts, though the natives were so accustomed to them, that they were able to kill them without danger or trouble, and very few accidents occurred in consequence.

Owing to the extreme dryness of the atmosphere, the wagon wheels had to be taken off periodically and soaked in water for about 48 hours, in order that the wood might swell sufficiently to prevent the iron tires from coming off.

The rainfall is very partial, and it would appear that the parts of the country which get the first showers continue to be rained upon during the whole season, while parts often get no rain. Sometimes on farms there appears to have been little or no rain for two or three years, and when this occurs the grass and shrubs become so dry that they catch fire like tinder, and great precautions have to be taken to prevent accidents in consequence.

Water-spouts are not unfrequent, and it sometimes happens that a pan which has been dry for some years will become suddenly filled with sufficient water to last for several years, it usually happening that a pan of water attracts the rain. Although there is so small a rain-fall, there is ample for irrigation purposes, were it properly stored. Except in the construction of small farm dams, no attempt whatever has been made to store the rainfall in any way, and it often happens that the rivers are full, while the lands through which they pass are so dry that the stock is wasting away from drought. The rivers flow at some depth below the level of the surrounding country, so that they overflow their banks only in exceptional seasons.

In many cases the farmers are nomadic, living all their lives in tents, and wandering from one pasture to another, owing to the excessive droughts. At these times they must bring down their flocks to the river side on account of the scarcity of water. This drought is sometimes so thorough that travelling from one part of the country to another is stopped. While the boundary survey was going on, a case of this kind occurred, and it was difficult to bring sheep from the Orange River to Kimberley. This want of water was a very serious hindrance to the surveyor, as he had frequently to carry enough not only for himself but for his animals. Horses require water twice a day in the dry weather, and the oxen, if they are thirsty, will stray to great distances, leaving the camp to its fate. There are very few fountains and the farmers supply themselves by dams, or artificial ponds; during the wet season these give moderately wholesome water, but after a drought the water is generally green, alive with animalculæ and strongly impregnated with the excrement of the cattle which stand in the mud during the heat of the day. The small charcoal filters we carried with us could not remove the disagreeable taste in these cases.

Our food was of the simplest kind, so far as the products of the country were concerned; some very dry bread, rusks, and tainted mutton, if we attempted to live in European style; but if we lived according to the ways of the country, the food was wholesome, consisting of biltong (meat dried in the sun in long strips), and cakes cooked on the embers, and as these embers were usually of cow-dung, the food whether meat or drink, had a *soupçon* of the live ox about it. Our meals were generally supplemented with tinned lobster, salmon, herrings, &c.

For example, the food which we would take when away from camp for a day or two would consist of a few pounds of Boer meal, coffee, sugar, two or three tins of lobster, and some biltong.

On account of the exhilarating effects of the climate, few stimulants are required, and work is best done on tea or coffee, in fact no man during the hot weather can drink beer or stout in the middle of the day for any time with impunity. There are many however in the country who consider that alcohol is good for the system, and drink it in any form whenever they have an opportunity.

After having completed our work around the base line of verification at Kimberley, we proceeded to the Riet River to fix David's Graf (Appendix H), arriving there 21st January. We remained on the bank of the Riet River about eight days, observing at the stations around, selecting the David's Graf station for the boundary line, and determining the direction of the line to Ramah (about 43 miles) by connecting M. Orpen's triangulation with our own. While we were here one of our party became extremely ill; he could not eat the food of the country, and became so emaciated that when I returned from observing on the evening of 23rd January, I found him in a state of collapse, and gradually sinking from exhaustion; I was obliged to force food down his throat, much against his will, and by constant attention during the night brought him round, and in a few days he became convalescent; one native was also ill at the same time with inflammatory symptoms, due to the fluctuation of temperature, it being now the middle of summer.

The laying out of an alignment for a distance of 43 miles between two points by an azimuthal angle is a very interesting operation, and many were the speculations which we made as to the exactitude with which we could do it (see Appendix F). At this distance every second of error in azimuth would be subtended by about one foot on the earth's surface, and as I did not think we could possibly work to within ten seconds, I expected to be within ten feet of the centre of the pile. We were not satisfied with fixing one point for our alignment at starting but laid down several, with both 12″ and 10″ theodolites, thus obtaining a mean position for our first forward station from points whose errors of alignment only differed three or four inches in themselves, but still sufficiently to throw us out in the long run if they were not eliminated as far as practicable. This system was carried out throughout, and accounts in a great measure for the success of our alignment, which struck the pile at Ramah within three feet of the centre.

This work occupied us several days, and we continued at the same time the observations from the trigonometrical stations near at hand. The work was very trying, as the line passed at long distances from tents, and we were for hours without food or water, and had to bivouac as best we could.

We arrived at Ramah on the afternoon of Saturday, 8th Feb., and having thus accomplished this portion of our line sucessfully, proceeded to Fredericksfontein, a few miles to the north-east of Ramah, where there was a flat pan for three miles in length, on which we had determined to measure our base line.

The weather was very dry at the moment, and there was little food for our oxen, which caused them constantly to stray, and gave us considerable work; our native drivers were no good, and I had on more than one occasion to assist in the search on foot, and had the gratification of finding and bringing them in myself. The searching for oxen is rather an interesting proceeding: when it is determined that they are lost, each person settles in his own mind where they are gone, the party spreads out in every direction and endeavours to spoor them. Sometimes if they are thirsty, or are suddenly filled with a desire to return to their native haunts, they will move off at three to four miles an hour, and are most difficult to catch up on foot.

The account of the measurement of the base line at Fredericksfontein is given in the Appendix. In addition we took observations for latitude and azimuthal bearing of base line.

We were very much concerned about the weather, for at any time the flat pan, which we used as a base line, might be converted into a sheet of water in a few minutes.

Fortunately the rains did not come on until 19th February, when we had completely finished our work in the pan.

Having now taken the greater part of our observations required for the triangulation, and measured our base line, we proceeded to Ramah, 23rd February. The weather was very cold at night in consequence of the rain, and I took pity upon the ox leader, giving him a blanket and rough coat, and as a consequence he disappeared next day, as is usual with these natives, to pawn his coat, and we saw nothing more of him: we were thus left in difficult circumstances, as the other help had on our former visit to Ramah endeavoured to stab the cook, and had in consequence been dismissed.

We now began to put up the beacons on the line, and connected them with the triangulation, commencing at No. 1 on the Orange River, and proceeded slowly back again to David's Graf, erecting the twenty beacons as we proceeded. For this work we were fortunate enough to be able to hire a few Kaffirs at Zwinkspan, for as a rule it is extremely difficult to hire labour near the Diamond Fields, as the chance of secreting a diamond in the mines draws the natives there.

We had to work hard ourselves, and I found that we could put the Kaffirs to shame in any manual labour. We had to follow the boundary line, as I had to sketch in the detail, while our cart had often to go many miles round on account of the cropping up of the trap rocks; we were thus often cut off for hours from our tents and food, and sometimes we could not be found by our drivers or could not find our wagons ourselves.

I made it a rule if any man should be away, even for two or three days, to put up a lantern at night on a pole near the wagon, because it was easy to get lost, and the lantern could be seen at a great distance.

We arrived at the junction of the Riet and Modder Rivers the 8th March, but were unable to cross on account of the rain having come down that day; it was rising rapidly, and as we were looking on a wagon stuck in the drift; two spans of bullocks were put on without effect, and it was supposed that the wagon would be swept down the river. A third span however was tried on, and then the wagon was dragged out just in time. We were thus cut off from our work, and as these rivers are often down for four or five days at a time, we were afraid that we should be considerably delayed.

I therefore determined to attempt to cross the rivers above the junction, and went to David's Graf, where there is an old drift, which wagons had not attempted for many years; here the volume of water in the Riet River was not half what it was at the junction. I emptied the wagon, successfully got it down the very steep side of the drift, and dragged it across, and then had the contents taken over on the heads of the natives; we were now between the two rivers on a tongue of land which is sometimes flooded. On the following day, 12th March, we attempted to cross the Modder River and having a farmer in front of us with another wagon, we were able to ford it without great difficulty.

We now (15th March) proceeded to lay down the line between David's Graf and Tarantaal Kop (33 miles), and were enabled to execute this work very rapidly, as about midway the line cuts a Kop in the neck at Scholtz's Dam, from whence both points could be seen.

Whilst here engaged, a deputation from the London and South African Exploration Company waited upon me, requesting that for their individual interests I should make a deviation from the line so as to bring all their land into British territory; they brought a letter of introduction from the Administrator of the Province.

At the same time I received a memorandum from the Administrator, asking me whether I considered my instructions would enable me to deal with the matter. About my discretionary power I had no doubt, but I did not consider it necessary to use it in this case, and replied—

"* * * With regard to Mr. Coryndon's suggestions (in his letters of the 13th February and 14th March) that the property of the Manager of the London and South African Exploration Company and others should continue to be in British territory, I would point out that such a suggestion if applied to the whole property over which the line passes, is simply a proposal that the whole line be moved in a zigzag direction, here some miles to the east, here some miles to the west of the line agreed on, according to the individual wishes or interests of the owners of property, and without reference to the interests of the States concerned.

"As Mr. Coryndon has, in order to further the interests of his clients, shown his appreciation of the absorbing importance of the public interests over those of private individuals by adducing two points regarding the interests of the public, I am sure he will fully understand the necessity for tracing the line in compliance with the Memorandum of Agreement between the Earl of Carnarvon and His Honour the President of the Orange Free State, and in accordance with the instructions issued to the two experts to whom the work has been entrusted."

Finding that I was not disposed to give way in this matter, an agitation was got up in the local papers, stating that the traffic to Kimberley would be interfered with, because a portion of the main road near Margersfontein was cut into the Orange Free State, a proposition which was manifestly ridiculous because the road over the Veldt could be altered at any time in a day, should any inconvenience arise.

A more serious difficulty, however, arose when it was found that some officious officials at Jacobsdaal (Orange Free State), who were interested in the matter, were actually exercising jurisdiction over this road immediately on our laying down the line, before it was proclaimed or completed, a proceeding which I felt sure was directly contrary to the wishes of the President.

I therefore, in company with my colleague, proceeded to Bloemfontein (120 miles) on 21st March, and consulted with the President on 23rd March, and enquired from him whether the fact of this road overlapping into the Orange Free State had been noticed at the time the agreement was drawn up, and whether he could suggest any arrangement. At the same time I presented to him a letter from Major Lanyon regarding the preservation of the old boundary until the new one should be proclaimed. The President at once sent an express to the officials at Jacobsdaal, ordering them to adhere to the boundary then in force, and not to give trouble on the road at Margersfontein, and at the same time he assured me that the fact of the overlap of the road into the Orange Free State would not be a source of trouble in any way, and had been known at the time of the agreement. He entirely concurred with me in considering that no deviation from the line could be made to suit individual interests without causing discontent among the majority of land owners on the line, who would all wish the line changed hither and thither to suit their individual interests.

I arranged at the same time with the President that on the completion of the beacons on the boundary line, they should be pointed out by us to officials on both sides of the line, in order that they might be preserved intact until they came into use.

I returned from Bloemfontein on 24th March, arriving at MacFarlane's station, opposite Tarantaal Kop, on 26th March. During our absence considerable progress had been made in building up the beacons we had laid out on the line between Scholtz's Dam and Tarantaal Kop, which are placed at the close interval of about one mile apart, on account of the proximity of the Diamond Fields.

We now proceeded to settle the point at Platburg, and selected the centre of the flat summit, and having done this commenced to trace the line from Platberg to David's Graf, which we had to continue throughout its length, although we only used it as a boundary line so far as a point opposite to Tarantaal Kop.

So far as this point, Platberg could be seen, about 30 miles off, but beyond to south, the ground was undulating and the line had to be carried on in short lengths; on this account it was necessary to calculate the azimuth from Platberg. This being done Mr. de Villiers placed himself at Platberg with his ten-inch theodolite, a large flag 12 feet square kept up by guys, and a piece of looking glass or heliostat, and proceeded to place me in line. I was on the hills at a distance of 30 miles from him, with a 12" theodolite and heliostat.

The taking up our alignment at a distance of 30 miles is not a long business to describe on paper, but it is a delicate and difficult operation on the ground, in a rough country, covered with brushwood and trees.

With the use of the large flag and heliostat we succeeded in keeping up a good communication and secured our position accurately; the line was then continued over the undulating ground past Kimberley down to the Modder River, and was found to our great satisfaction to cut within the diameter of the David's Graf beacon, showing not only that we had traced the line correctly, but also that our triangulation and calculations were rigidly accurate.

We had now to trace this line over the intervening country to Platberg, to fix the lines of the farms of Erasmus and Joubert and find their intersection with the main line; we had also to produce the line past Platberg to the Vaal River.

This involved incessant work night and day, during which time we were seldom able to rest in our tents, but carried on the work from point to point, sleeping out in the open wherever it best suited us. We also fixed the position of the right angle opposite Tarantaal Kop.

On 16th April, I went into Kimberley to report that we were ready for the line to be inspected, and found that the parties nominated were ready for us.

The 60 beacons which we had laid out on the boundary line were not yet all erected, but they were all in course of completion, and work on them could continue under the direction of Serjt. Kennedy and Corporal Randall while the inspection of the line was going on.

Accordingly, on 18th April, those who were nominated assembled at our camp at MacFarlane's Station. They consisted of

> The two Commissioners;
> Government Secretary, Orange Free State;
> Landrost, Boshof, ,,
> Veldt Kornets, ,,
> Acting Administrator, Griqua-Land West;
> Acting Surveyor General. ,,

We took our course to north, arriving at the farm of Erasmus that evening; next day we proceeded to the Vaal River and back to Erasmus. We had now to get fresh horses and we travelled down the line to Ramah, being met on the way by the landrost of Jacobsdaal and Civil Commissioner, Langford. We arrived at Ramah on 22nd April.

Adolf Erasmus, the fervid Republican, whose farm had been by special agreement cut into the Orange Free State, was now so favourably impressed with the British Government that he had insisted on carrying me down the boundary line in his own cart.

Our journey of inspection was far from disagreeable; we numbered about 12 persons in all, and there was a general desire on the part of all to make merry over the satisfactory completion of the line.

We arrived at Jacobsdaal on 24th April, where my colleague and I united in writing the following report, so that it might be presented to the Volksraad at the opening on 1st May:—

"SIR, Jacobsdaal, 24th April, 1877.

"In compliance with the wish expressed by you to be informed whether the survey and boundaries of Griqua-Land West and the Orange Free State have been completed and settled, and the beacons erected as required by paragraph 4 of the agreement entered into between Lord Carnarvon and President Brand, dated 13th July, 1876, we have the honour to state that the line has been surveyed and the beacons erected in accordance with the agreement, the map of which will be completed within a month from this date.

"We have, &c.

(Signed) "CHARLES WARREN, *Captain, R.E.*

" "Jos. E. de VILLIERS.

"The Gov. Secretary,
"Orange Free State."

I returned to camp to complete our beacons on 25th April and succeeded in finishing them by the end of the month.

On 1st May, I wrote a report to the Secretary of State informing him of the completion of the field work; there now only remained the final calculation and drawing of the plans.

After visiting Kimberley and Barkly I proceeded to Boshof, Orange Free State, on 8th May, and commenced the calculations and construction of the plans on a scale of 3 miles to one inch. These we completed in time to allow of our proceeding to Bloemfontein on 15th May.

On 17th May I was asked by President Brand to meet the Volksraad at the annual official dinner. At this time there was a very strong feeling against England in the Orange Free State, in consequence of the annexation of Griqua-Land West and the Transvaal, and there was some hesitation about proposing Her

Majesty's health coupled with Great Britain and Ireland amongst other toasts, it being supposed that whoever responded would not be received favourably, and that a disturbance would arise; hearing of this I begged that matters should proceed as in former years and engaged that the Boers would not be displeased. As a result, the toast was received with acclamation, and cordiality was for the time restored.

On 19th May we finally handed over to President Brand for his signature our plans of the boundary line, and forwarded them to England.

On 21st May, I returned to Boshof, gave directions for the N.-C. Officers to proceed to England *viâ* Cape Town, and proceeded myself to Kimberley and thence to Pretoria and the Gold Fields to Delagoa Bay, intending to go to England by Zanzibar. I was, however, directed to return to Cape Town from Delagoa Bay to see His Excellency Sir Bartle Frere, and on arrival there was requested by him to accept an appointment for six months as Special Commissioner in Griqua-Land West, to investigate and arrange the various land cases in appeal upon the high land of Griqua-Land West.

Votes of thanks were passed by the Orange Free State and Legislature Assembly of Griqua-Land West on the completion of the boundary line, and forwarded to their two Commissioners.

APPENDICES.

Appendix A.

Two base lines were measured for the Boundary Survey; the first over a distance of three miles at Fredericksfontein, on the Orange River, the second (used as a base of verification) over a distance of 2,000 yards, and prolonged by triangulation on the original base near Kimberley, which had been previously measured with a chain, for the Farm Survey of Griqua-Land West. The first mentioned base line was measured on a perfectly level and smooth surface, the second sloped irregularly from S.W. to N.E., and the surfaces were made smooth artificially by the aid of the spade.

The actual measurements of the base lines were made by means of three deal rods laid successively on the surface of the ground, each rod abutting on that previously laid.

The staves or rods were each cut out of seasoned deal, about 1¾ inches square, 12 Cape feet long, shod with sheet zinc and painted white. The ends of each rod over which the zinc was laid were cut square; but actually, the zinc at centre of end of each staff projected almost imperceptibly, yet still sufficiently to ensure the contact of the rods being always at the same spot.

This was a most important item in the construction of each rod, ensuring much closer and more accurate measurements than could have been obtained with ends carefully squared; at the same time this imperceptible bulge at the centre did not produce any vacant space between the zinc and the wood sufficient to cause it to *give*, when one rod was pressed in against another.

These rods both before and after the measurements of the base line, were tested over the distance of 360 feet with two standard Cape rods, each 6 Cape feet in length. The deal rods being laid flat on the surface of the ground as in measuring the base line, while the standard rods were laid over them.

There were two sets of standard rods available, of identical pattern; one set had been received direct at Kimberley from Cape Town some years before, the other set was supplied by the Orange Free State Government, to whom it had recently been presented by the Cape Government.

The difference between these two sets of rods was not so great as the difference in each rod itself, as will be explained hereafter, so that practically they may be assumed to have been of equal lengths.

These standard rods were made of mahogany, each 6 Cape feet in length, the ratio of the Cape foot to the English foot being as follows:—

10 Cape feet = 10·33 English feet.
72 Cape inches = 74·376 English inches.

The work in hand was therefore

(*a.*) To obtain measurements of each base line in terms of the deal rods.
(*b.*) To compare the deal rods, for ten sets (about 360 feet) with Cape standard rods.
(*c.*) To ascertain, as far as practicable, the accuracy or actual limit of error of the standard rods.
(*d.*) To reduce the length of base line in terms of corrected standard rods, from Cape feet to English feet.
(*e.*) To work out the ordinary reductions of the base line to the level of the sea.

The Kimberley standard rods were first tested in themselves by means of one English standard, and though their mean length of 12 feet, 4·600 inches, closely agreed with that of the Orange Free State rods of 12 feet, 4·603 inches, yet there was too great a difference on the edges, and consequently these rods were not used, though for all general purposes they were sufficiently accurate. Their defect appeared to be that the iron shoes at either ends were not perfectly square, and consequently each edge measured a different length. The same defect also attached to the Orange Free State rods, but not to the same extent.

These latter rods were next tested in themselves, and it was found that the rods *together*, gave far more accurate results than when measured separately, and it was surmised that as standards they were only to be used as one rod. The following observations may prove of interest:—

$$\text{1st Edge} \begin{cases} \text{Rod A., } 6'\ 2{\cdot}295'' \\ \quad ,,\ \text{B., } 6'\ 2{\cdot}306'' \end{cases} A + B = 12'\ 4{\cdot}601''\ (\text{English.})$$

$$\text{2nd}\ ,, \begin{cases} \quad ,,\ \text{A., } 6'\ 2{\cdot}310'' \\ \quad ,,\ \text{B., } 6'\ 2{\cdot}307'' \end{cases} A + B = 12'\ 4{\cdot}617''\quad ,,$$

3rd Edge $\left\{\begin{array}{l}\text{Rod A., } 6'\ 2{\cdot}280'' \\ \text{,, B., } 6'\ 2{\cdot}311''\end{array}\right\}$ A + B = 12′ 4·591″ (English.)

4th ,, $\left\{\begin{array}{l}\text{,, A., } 6'\ 2{\cdot}290'' \\ \text{,, B., } 6'\ 2{\cdot}314''\end{array}\right\}$ A + B = 12′ 4·604″ ,,

Mean A + B = 12′ 4·603″ ,,

These descrepancies, which thus in the rods themselves amounted to ·026 inches in 12 feet, or about 11 inches in a mile, were found to be practically eliminated, very nearly, when these rods were measured together over a distance of from 300 to 360 feet. The distance they measured being found to agree almost exactly with the mean of the lengths of the edges, which amounts to 12 feet, 4·603 inches (English). It was therefore decided not to trust to the measurement of one set of standard rods, but to test these rods with the deal service rods over a distance of ten sets of deal rods, or about 360 feet.

The next operation was merely one of comparison, in order that it might be satisfactorily ascertained that the standard rods were the length they professed to be. For this purpose the two standard rods were laid down on a smooth board, and a line drawn at each extremity with the sharp edge of a knife, giving exactly the lengths on the sums of the rods A and B.

The tests used were an electrum graduated straight edge (standard) belonging to the Surveyor General, and a standard 42-inch rod of boxwood (by Elliot), brought out by Captain Warren, and were applied by the aid of a strong microscope, with the following result:—Thermometer F. 80°

1st Measurement A + B = 12′ 4·625″ English.
2nd ,, A + B = 12′ 4·630″ ,,

Mean 12′ 4·627″ ,,

Along edges 12′ 4·624″
,, 12′ 4·630″

Mean of edges 12′ 4·627″

Now the length of the Cape rods should be 12 feet, 4·752 inches (English), and it is therefore evident that this error of ·125 inch in 12 feet, lay either in the standard Cape rods, in the standard English measures, or partially in each.

No practical conclusion could be arrived at as to where this error lay, because Kimberley is about 700 miles from Cape Town, at a difference of level of about 4,000 feet, with a totally different climate, and during the journey backwards and forwards it was not practicable to ascertain the exact change that would take place in any of the wooden standards used. The electrum standard was sent down for comparison, but the exact ratio of expansion and contraction of electrum for various degrees of heat, could not be ascertained. The probabilities were that the English standard had altered, if originally correct, by change of climate, and that the Cape standards were of the same length nearly as when they had left Cape Town. It was, moreover, considered desirable that the preference should be given to that standard which was in use in South Africa, by authority. The Cape standard rods (A + B) as measured over a distance of 360 Cape feet, were therefore assumed to be the length they professed to be, viz:—30 × 12 feet, 4·752 in. (English), and this was the standard used in measuring the base lines.

The next process was to test the deal rods with the Cape standard rods, and as a preliminary operation, the Kimberley standard rods were laid out over a distance of 72 Cape feet, on the smooth verandah of the Surveyor General's Office, and in two successive measurements (29th December, 1876), the deal rods were found to be too short by a mean of ·773 inch, (·766 inch and ·781 inch.) This would give 3·865 inches in 360 feet, whereas with the Orange Free State rods it was only 3·535 inches, being a difference of ·330 inches in 360 feet, or about 4·8 inches in a mile. I have already stated that the Kimberley rods were not used in the actual operations, and I merely give this result to show what was practically the defect of the Kimberley rods, and from which it will be seen that unless most minute accuracy is obtained in the original standard, it is of little use attempting to measure a base within certain limits of accuracy, say two inches to a mile.

After some further testing of the deal rods with the standard rods, the party proceeded to measure the Kimberley base, which was used in the survey as a base of verification.

This Kimberley base, which had four years before been measured by Mr. Surveyor Ford (a very experienced and accurate surveyor), for the Surveyor General, was found to be too rough at its northern extremity for very accurate measurements, it was therefore divided into two portions (during the first week in January, 1877), and the point of division marked by a stone sunk in the ground to about nine inches below the surface, with a △ marked thereon, it was arranged to extend the northern portion by triangulation, and the southern portion thus cut off measuring about 2,000 yards in length, was carefully cleared of the shrubs which had grown up during the previous four years, and the ground for a width of about 12 inches was cut into a series of plane surfaces by the men in camp, assisted by a gang of six convicts from Kimberley gaol. This work, commenced on 1st January, 1877, was completed early on Tuesday, 9th January. The measurement of the base line was commenced on the morning of Tuesday, 9th January, by aid of the three deal rods already mentioned. As previously mentioned, they were constructed to measure 12 Cape feet each, though actually they were somewhat short.

A 7-inch theodolite was put up at S.W. end of base, and by its aid iron pegs were driven about one inch from the actual line, and at about 30 yards apart; from peg to peg a line of string was strung, along which the rods were to lie.

Although the base line consisted of a series of plane surfaces, yet it was considered desirable that the measurement of the line should run through without a break, so as to ensure the most perfect accuracy of through measurement attainable under the circumstances, so far as the total length along the series of plane surfaces was concerned. This was considered to be practicable, because the slopes differed very slightly one from another. The angle of these slopes to the horizon, was obtained by means of the theodolite, the distances of points of change from slope to slope, from origin of base line, being noted.

Accordingly the measurements were taken throughout without any break in the line from S.W. end to the sectional point, and the results of the various measurements, compared one with another, proved most successful.

1st measurement, 184 sets + 2 rods + $5' \, 6'' = 6{,}653' \, 6''$
4 hours, 51 minutes, from 10 a.m. to 5 p.m.

2nd measurement, 184 sets + 2 rods + $5' \, 7\frac{11}{16}'' = 6{,}653' \, 7\frac{11}{16}''$
3 hours, 37 minutes, from 5.30 a.m. to 9.30 a m.

3rd measurement, 184 sets + 2 rods + $5' \, 9\frac{3}{4}'' = 6{,}653' \, 9\frac{3}{4}''$
2 hours, 20 minutes.

The third measurement was taken very rapidly, merely to test the other two, and to ascertain what would be the effect on the measurement of the line when executed rapidly, and the results show the great accuracy with which measurement with deal rods can be made in a dry climate, when the line is run right through without a break.

The system of measurement adopted was as follows:

The rods were painted white and numbered I., II., and III. No. III. being painted black for about one foot at either end, to distinguish it from the other two. In the first place, No. I. was laid down along the line of the base by Serjeant Kennedy, commencing from the centre of mark at S.W. end, and the position was verified by Captain Warren. Serjeant Kennedy then crept to the forward end and gently placed his foot firmly upon it (the ground underneath being extremely hard, solid and smooth), and remained there till Nos. II. and III. had been placed in position thus:—A labourer brought forward No. II., and placed it so as to abut on No. I., Serjeant Kennedy adjusting the contact. Captain Warren then placed No. III., in line with Nos. I. and II., and abutting on the latter, on the forward end of which the labourer had previously placed his foot. After seeing to the close contact of Nos. II. and III., Captain Warren stood on the forward end of the latter, marked the tally, and noted the distance in his field-book, while at the same time Serjeant Kennedy made a similar observation in his book. The tallies were entered in columns of ten each, so that each represented 3,600 Cape feet.

After a short time the party became very expert in taking these measurements rapidly, and the knees were used instead of the feet for keeping the rods firmly fixed in their places.

In comparing the deal rods with the standard rods on the base line, the former were laid down as in measuring the base, and the latter then laid over them, and abutting one on to the other in succession. At the end of 360 Cape feet, it was found that the deal rods were too short by a mean of 3·538 inches, the extremes being 3·55 and 3·525 inches. The same comparison was again made, returning the same distance, when the deal rods were found to be less than the Cape rods by a mean of 3·6 inches, giving a mean defect of the deal rods at this time of 3·568 inches in 360 feet.

Fredericksfontein Base Line.

About twelve miles north east of Ramah, on the Orange River, within the boundary of the Orange Free State, there is a long pan, a dried up bed of a lagoon, in length nearly north and south, or more correctly speaking in the same direction as the boundary line itself. It is about three miles in length and six hundred yards in width.

At the southern extremity there is a spring of water called Fredericksfontein, and due east of the centre of the pan, at a distance of about four miles, is a conical hill, rising about 250 feet above the bed of the pan, which can be seen from all sides up to a distance of about twenty miles.

The bed of the pan is perfectly level and, for about two miles in the centre, is extremely smooth. About six hundred yards of the southern end is somewhat rough, owing to the constant tramping of sheep on the smooth surface, when going to and returning from the fontein. At the northern end, the pan-bed is grown over with low shrubs.

As a whole, the pan presents a perfect site for a short base line. There is nothing to be compared to it within the British Isles. It is ready for the laying down of a base line; no spade work being required, except at the northern end where a few shrubs require to be removed. The dead level of the pan-bed may be known by the fact that, after a thunderstorm, the water lies on the bed in one long unbroken sheet during calm weather at an uniform depth; but when the wind blows strongly and continuously, the water is blown over to the leeward side and heaped up there; so much so, that should there be a sudden change of wind, the water will be driven in a wave from one side to the other, the dry portion being in a short time covered up to a depth of one or two feet, while what was covered with water is now left dry.

The survey party arrived on Friday, 9th February, 1877, and encamped near Fredericksfontein, and in the evening Mr. de Villiers and Captain Warren selected the line of base, and sunk stones at the northern and southern ends of the pan, nearly three miles apart, to mark the extremities of the base to be measured. At about the centre of this projected line a flagstaff was also put up, dividing the line into two nearly equal sections.

On 10th February, at sunrise, Captain Warren, assisted by Serjeant Kennedy, laid out and picketed, from its southern extremity, about a mile and a half of the base line, while at the same time Mr. de Villiers correctly aligned the northern extremity with the southern and sectional points. In the forenoon of the same day the measurement of the base line was commenced from the southern end, and was carried out in a somewhat similar manner to that described in the account of the Kimberley base.

Mr. de Villiers had charge of No. I. rod, Serjeant Kennedy of No. II., and Captain Warren of No. III.

Owing to the want of sufficient string for giving the alignment between the pickets, the progress was comparatively slow; 230 sets of rods were measured up to the sectional point, and this occupied 8 hours, 30 minutes, from 10 a.m. to 7.30 p.m., allowing one hour for lunch.

On the afternoon of the following day (Sunday, 11th February) Mr. de Villiers and Captain Warren laid out the line by pickets for a few hundred yards from the section point, so as to be ready for the morning.

On Monday at daybreak, a stone was sunk at the sectional point of base, and at 7.30 a.m. the measurement of the base was continued. The measurement of every ten sets of rods was then found to occupy about 12 minutes, so that the north end of base was reached at 1.28 p.m., an hour having been occupied for lunch.

The northern extremity of base was fixed at the termination of 210 sets of rods from the sectional point, and 440 sets of rods from the southern end of base; and as each set of rods is assumed to equal 12 yards, this measurement gives roughly 5,280 yards, or three miles as the length of the base line. The exact measurement is given below.

The measurement of the base from north to south was commenced on same day at 2.17 p.m., the rods managed as before. For the first 400 yards the rate was about ten sets in 12 minutes, but on getting on to the perfectly smooth part of the pan, it was not considered necessary to have *two rods out of three* fixed always at the same time; therefore only one was kept fixed at one time, and the rate was accelerated to ten sets of rods in $4\frac{1}{2}$ minutes, or a pace of 1,560 yards per hour.

On reaching the sectional point, at 4.30 p.m., the rods were found to overlap upon the first measurement by one quarter of an inch.

The measurement was now continued at the rate of about ten sets of rods in 5 minutes, and the southern extremity of base was reached at 7.20 p.m., at about 20 minutes after sunset. On arrival at this point, it was found that the deal rods did not come up to it by 2·5 inches.

Thus on the re-measurement of the second section (with the 230 sets of rods) the second measurement was less than the first by only one quarter of an inch, while in the re-measurement of the first section (with the 210 sets of rods), the second measurement exceeded the first by 2·75 (·25 + 2·5) inches.

Now it is to be noted that the measurement and re-measurement of the second section took place on one day, the 12th February, between 7.30 a.m. and 4.30 p.m., whereas the measurement of the first section took place on 10th February, between 10.30 a.m. and 7.30 p.m., while the re-measurement took place two days after, on 12th February, between 4.30 p.m. and 7.30 p.m.

Thus, in the case when the discrepancy was only a quarter of an inch, the two measurements took place under nearly precisely similar circumstances, whereas in the case where the discrepancy reached 2·75 inches, the re-measurement took place after the interval of nearly 48 hours, and at a different time of the day.

The question therefore arises. How are these discrepancies to be distributed or disposed of, and on which measurement can most reliance be placed?

In the first place, it is possible that between 10th and 12th February the rods may have met with some minute injury during the time they were not in use, which may have reduced their length by about ·005 inch, or this may have happened after the re-measurement of the second section on 12th February. On the other hand, during the interval of 48 hours, the atmospheric changes may have affected the length of the rods to this slight extent, and again, the second measurement of the first section having been made wholly after the heat of the day had passed away, the difference of temperature might have altered the length of the rods to this minute extent.

The discrepancy, however, of 2·75 inches in about 2,760 yards is only ·00003 inches per cent., is far less than the average discrepancy in accurate measurements of base lines, and therefore a mean was taken.

Even with compensation bars it is difficult to arrive at such close results as those obtained here.

See, for example, Captain Bailey's "Report of the Measurement of the Base Line for the Cape Triangulation," in which there was a discrepancy of eight inches between the two measurements of a section about a mile and a half in length.

See also the discrepancies between the various measurements of the Salisbury Plain Base and Hounslow Heath Base, which exceeded those on that of Fredericksfontein.

It is obvious that in a dry climate like that of the Orange Free State, wood would not be affected to the same degree as in the humid climate of England, so that deal rods, which in England might be very imperfect standards of measurements, may in a dry climate be as nearly perfect standards as could be used.

After the measurement of the base, on the night of 12th February, the deal rods were carefully covered up, and were brought out and tested with Cape standard rods on following morning.

These rods were tested one set over the other for a distance of twenty sets (or 720 Cape feet), when it was found that the Cape rods over-lapped 5·025 inches, by Captain Warren's observation, and 5·05 inches by that of Mr. de Villiers.

Leaving the last rod with this over-lap, the re-measurement was made, and on arrival at the extremity of the first ten sets of rods, the over-lap was reduced to 2·4 inches, and on arrival at the starting point, the Cape rods, instead of coinciding with the deal rods, over-lapped 0·15 inches by Captain Warren, 0·16 inches by Mr. de Villiers. This would give 2·541 English inches as the defect of the deal rods when compared with the Cape rods in 360 Cape feet.

Now it will be observed on reference to page 31, that the defect of the deal rods on the Cape rods, in the measurement of the former base line, on 11th January, 1877, was 3·568 English inches in 360 Cape feet; from which it would appear that the deal rods had, during the interval, increased in length one inch in 360 feet. This may be accounted for by the fact that in bringing the rods from Kimberley, some extraneous matter at the end of No. 3 rod had become wedged in between the wood and the zinc, bulging out the zinc about ·1 inch.

Now it was found that ten sets of deal rods were less than 360 Cape standard feet by (2·541 English inches =) 0·20498 Cape feet.

Therefore 210 sets of deal rods equal 21 (360 − 0·20498) Cape feet
= 7805·035 English feet,
and 230 sets of deal rods equal 23 (360 − 0·20498) Cape feet
= 8548·371 English feet.

$$\text{A B measured} \left.\begin{array}{l}\text{1st 21 sets} \\ \text{2nd 21 sets} - \cdot 020'\end{array}\right\} \text{mean} = 7805{\cdot}025 \text{ English feet.}$$

B C measured 1st 23 sets / 2nd 23 sets + ·229 } mean = 8548·485 English feet.

Reduction of Base to level of the sea.

r	=	20923599·9	Log. =	7·3206364
BC	=	8548·485	Log. =	3·9318891
				11·2525255
r	=	20923599·9		
h	=	4000		
$(r+h)$		20927599·9	Log. =	7·3207194
B′C′	=	8546·85	Log. =	3·9318060
r	=	20923599·9	Log. =	7·3206364
A B	=	7805·025	Log. =	3·8923743
				11·2130107
			Log. $(r+h)$	7·3207194
A′B′	=	7803·53	=	3·8922913
A B′	=	7803·53		
B C′	=	8546·85		

Base at level of the sea = 16350·38 feet, English.

Previous to using this base it appeared desirable to test the section A B against B C by a triangulation, it was then discovered that the sectional point was four inches to the west of the line A C, owing to its having been placed in position when there was considerable lateral mirage. The same difficulty occurred to Captain Bailey in his triangulation of the Cape Colony, when measuring his base. He says (page 19), "Next morning the position of the bandrols in line was tested. The centre bandrol appeared still exactly in line, and was not altered in the least. Some of the intermediate ones, which had been placed when there was considerable motion in the air, were altered laterally, but only two or three inches at the most; subsequently the centre bandrol was frequently observed and appeared to be in an exceedingly accurate line, and most trifling deviations which could not effect the measurement was just observable in some of the others."

It will be seen from this extract that there is great difficulty, in short distances, in placing objects in a line, on account of the extreme *later* refraction along the surface of the ground, due to the very heated condition of the earth, in contact with the cooler atmosphere.

With this known deviation of the sectional point B, from the straight line AC, the section AB was calculated from the reduced measurement section BC (8546·856 feet) with the following results, in four separate triangles.

giving an extreme variation of ·55 foot.	7803·34	feet.
	7803·22	,,
	7803·77	,,
	7803·47	,,
Mean	7803·45	,,
Reduced measured distance	7803·53	,,
	·08	,,

From this it appears that the sections of the base have been measured extremely accurately, the mean calculated distance differing from the measured distance of section AB by only 0·08 foot, or 0·96 inch.

Appendix B.

Azimuthal Bearing of Base Line.—For these observations the larger theodolites were not adopted, and the seven-inch theodolite alone could be used, an instrument which read but indifferently to ten seconds, so that the mean of a series of observations could not be depended upon to less than five seconds.

Trials were made as to the most accurate method of obtaining the azimuthal bearing with this instrument, and it was found by experiments that the closest results were obtained by means of observations of equal altitudes of the sun. This may be due to the fact that in each of these observations a mean of four altitudes was obtained before the calculations were commenced, when with greatest elongations of stars only one observation could be obtained in each case. Moreover, it being now the middle of summer, the nights were too short for obtaining both the greatest elongations of the same star.

The line referred to the true azimuth was S.W. end of base (Kimberley) to Patterson Δ, and was taken in the calculations as

9° 14′ 29·4″ West, but the finally corrected angle differs three seconds, as shown below:—

	9° 14′ 33·0″
	9° 14′ 35·5″
	9° 14′ 30·5″
	9° 14′ 29·6″
mean	9° 14′ 32·15″

This bearing was carried through the triangulations down to the Fredericksfontein base when it read on the line

as	19° 27′ 2″
correction for convergency of meridians	8′ 55·8″
	19° 35′ 57·8″
whereas the azimuth, obtained astronomically at this base, amounted to	19° 36′ 7·2″
difference	9·4″
The observations vary as follows:—	19° 36′ 19·8″
	19° 35′ 56·9″
	19° 36′ 2″
	19° 36′ 11″
mean	19° 36′ 7·4″

This result was quite as near as could be expected from the instruments used, and was quite sufficient for the work, showing that the triangulation had been accurately brought down.

The equal altitudes were obtained in the following manner:—The vertical arc was clamped at an angle of elevation, say 56 degrees, when the left and upper limb were observed and azimuth angle booked, then the angle of elevation was increased to 56° 30′ and the right and upper limb were observed, and azimuth angle booked, then the right and lower limb at same angle of elevation, and finally the elevation was increased to 57 degrees, and the left and lower limb observed. These four observations generally took about six to seven minutes, according to the time of day, and allowed about two minutes between each, which was sufficient for booking and altering the angles.

In the afternoon the operation was repeated in inverted order the limbs now observed being RL, LL, LU, RU.

The mean of each of these sets of four observations was taken as azimuth angle of the centre of the sun's disc when at the mean angle of elevation, and these results were found more satisfactory than those given by any other system which was tried.

The great difficulty was the observation of the referring object for, owing to the state of the atmosphere and intense heat, it sometimes showed an alteration of 15 seconds.

CORRECTIONS FOR CONVERGENCY OF MERIDIANS.

Latitudes assumed.—South end of base, Kimberley, lat. 28° 43′ 15″, P. Dist. 61° 16′ 45″ S.E. end of base, Fredericksfontein latitude 29° 35′ 11″, P. Dist. 60° 24′ 49″. Difference of latitude, 51′ 56″. Sum of polar distances 121° 41′ 34″, mid polar distance 60° 50′ 47″.

Difference of longitude (by triangulation) nearly $18\frac{1}{2}$ miles = 97·680 feet = 0° 18′ 20·8″ of longitude at latitude 29°.

$$\left(\frac{18' \, 20{\cdot}3''}{2}\right) = 9' \, 10{\cdot}1'' \quad \text{Log. cot.} \quad 12{\cdot}5740614$$

$$25' \, 58'' \quad \text{Log. cos.} \quad 9{\cdot}9999876$$

$$60^\circ \, 50' \, 47'' \quad \text{Log. sec.} \quad 10{\cdot}3123348$$

$$\text{log. cot.} \tfrac{c}{2} = 12{\cdot}8863838$$

$$90^\circ - \tfrac{c}{2} = 89^\circ \, 55' \, 32{\cdot}1''$$

$$\times 2$$

$$179^\circ \, 51' \, 4{\cdot}2''$$

$$\text{convergency } c = 8' \, 55{\cdot}8''$$

$$180^\circ \, 0' \, 0'$$

APPENDIX C.

Longitude.—It had been decided to ascertain the longitude of Kimberley by means of telegraphic signals from Cape Town, but on arrival at Kimberley it was ascertained that the Surveyor General (Mr. Orpen) had in 1874 taken advantage of a total eclipse of the sun, and had made careful observations which were worked out at the Royal Observatory, Cape Town.

The results were as follow:—

Longitude of Radloff trigonometrical station, by observations of total eclipse.

1h 38′ $43\frac{1}{2}$″ E. of Greenwich.

24° 40′ 52·5″ E. of Greenwich.

Latitude of Radloff obtained on same day, by *transits of several stars on prime vertical* with 8-inch theodolite.

28° 41′ 34″ S. latitude.

On these observations the Astronomer Royal remarked that he considered the longitude to be exact to *half a second*, but he did not consider the latitude to be very exact.

It was thus clear that for the purposes of the boundary survey there was no object to be gained by taking observations for longitude, as the position of Radloff trigonometrical station with reference to the S.E. end of base was known.

The longitude and latitude of S.W. end of base were now obtained from the station at Radloff, with the following results:—

Longitude, 24° 55′ 9·11″ East of Greenwich.
Latitude, 28° 40′ 21·28″ South of Greenwich.

The longitude as above was accepted as correct on the authority of the Astronomer Royal, while observations for corrected latitude were made with the following result:—
Latitude of S.W. end of base by Captain Warren, 28° 43′ 15″ South.

Latitude.—Observations for latitude were made at south end of Kimberley base with seven-inch Altitude and Azimuth Instruments, and with eight-inch sextant, with the following results:—

	Latitude South.
Mean of stars, north and south, meridian altitudes with seven-inch Altitude and Azimuth Instrument.	28° 43′ 11·3″
Mean of stars north and south, circum-meridian altitudes with eight-inch Sextant.	28° 43′ 9·5″
mean latitude, South.	28° 43′ 10·4″

Several observations of the sun gave, however, a mean approaching 28 degrees, 43 minutes, 15 seconds, and this latter mean was the latitude adopted in the Survey, having been obtained before the former calculations. It is to be observed that the difference of five seconds only subtends about 180 yards on the earth's surface, and it was not considered that the instruments available could be assumed, even with the most careful observations, to give accurate results within that distance. Practical experience shows that series of observations of north and south stars which may appear to eliminate all errors, and which may agree in their means even to one second of arc, cannot (when taken with the instruments above mentioned) be considered to give true results to within five seconds of arc.

Appendix D.

Observations.—The observations were taken by the two Commissioners and Serjeant Kennedy. Mr. de Villiers used his ten-inch theodolite, while Captain Warren used a twelve-inch theodolite which he had hired from Mr. Surveyor Girfillen. The seven-inch theodolite was not large enough for the work in hand, and was principally employed when angles of elevation were required (for equal altitudes and azimuthal lines). The ten-inch theodolite had four verniers which read nearly the same, while the twelve-inch theodolite had only three verniers, two of them most awkwardly placed; one of them could only be read with the left eye, and one could only be read when the vernier was pressed gently, nevertheless, the means of the angles taken with the twelve-inch were better than those taken with the ten-inch, whoever might be the observer. It was difficult to account for this.

One defect of the ten-inch was that although the wood of the legs was well seasoned, yet it was wood of the country which has a most aggravating custom of warping and altering with the atmosphere, so that the instrument if kept up a long time would move very slightly, this however also took place with the seven-inch; it was placed in the morning on the referring object and observed throughout the day and found slightly to change its position in a given direction.

The mirage or parallax caused by the tremulous vibratory motion in the atmosphere throws great difficulties in the way of observing. This phenomenon appears to extend throughout South Africa, but the illusion differs in different places.

On nearing Cape Town in the autumn of 1876, the writer saw the barren shore, about Saldanha Bay, transformed at mid-day into a beautifully cultivated coast, with numerous broad waterfalls running over into the sea. These apparent waterfalls were merely stretches of white sand, which showed forth their true barrenness when the sun was low.

When travelling up through the country, lakes of water are constantly seen on either side of the road, which reflect trees from their surface and have every appearance of reality. So much is this the case that even when a country is well known, the deception to the eye continues in full force, and owners of farms have been known to imagine that a down-pour of rain has filled up their pans, while they actually are simmering with drought; on the other hand cases have occurred where farmers have believed they were looking on a mirage, while a real pan of water from a recent atmospheric disturbance lay before them.

The hills of the up-country are very much affected by the mirage, and assume the appearance of huge haystacks, their bases diminishing towards the horizon.

During the heat of the day, a stick if placed up at a distance of a mile and viewed through a telescope, appears like a falling column of water glittering in the sun, and a beacon at a distance of three or four miles has the motion of a tongue or flame of fire.

During a calm the motion on the horizon is undulating and vertical, and the smooth sharp outlines of the hills resemble the rough edge of the moon at the first quarter, but when the wind blows hard the outlines have the swift onward movement of waves or billows, and give the observer an uneasy notion that his instrument is not firmly clamped, or that the hills are quickly and noiselessly gliding away. The stronger the power of the telescope the more apparent the motion, so that with a good glass, observing during the time of the mirage is no easier than with one of inferior quality.

During a stormy wind there is also a lateral refraction, so that if a series of bandrols are placed in a line, and again observed when there is no mirage, some of them will be found to be out of line.

The phenomena of the mirage appear to be in some measure due to the extremely heated state of the earth, while the superincumbent air is cool, consequently there is a constant rush of heated air from the surface of the earth ascending through the cool air; but this does not entirely account for the phenomena, and perhaps the dry electric condition of the air may in some measure assist.

Owing to the difficulty about the mirage, observations could not be taken during the day except for about an hour at sunrise and an hour at sunset, before and after the sun is on the horizon, and thus it was seldom practicable to observe from more than one station in a day. It was customary to drive or ride to a hill in the afternoon, ascend it before sunset and take as many rounds of angles as the state of the atmosphere would allow of, sleep anywhere at the foot of the hill and be up again before sunrise to complete the observations. This was done without tents or other covering, and though in dry weather it was not disagreeable, on cold and rainy nights it was most trying, as there was little wood to be obtained and we had to go out in search of cowdung before we could light fire enough to get a cup of coffee.

It has been often said that there is no mirage after rain, yet on several occasions it was found so strong as to prevent observing.

Apart from this mirage the air was extremely clear and objects could be seen from 30 to 40 miles with great ease; it was not always practicable to distinguish the points when in wooded country and then heliostats were used, which were of the simplest description and readily manipulated.

The greatest length of side of any triangle used was about 32 miles, the average length being 15 to 20 miles. The various beacons on the boundary line, 60 in number, were fixed by small secondary triangles. The observations were found to be very accurate, although time did not allow of a large series of rounds at each station; four to five rounds were usually taken. The average error in each triangle was from three to five seconds; the sides in the triangulation in every case differed less than a foot one from the other, and the base of verification as measured differed from that as calculated by only 0·46 foot.

The heights of the angles of triangles were calculated and applied in apportioning the errors.

The portions of the boundary line formed sides of the various triangles, and the length is here given:—

Ramah to David's Graf	=	223966·67	English feet.
David's Graf to Tarantaal	=	174674·00	„
Tarantaal to the Right-angle	=	241982·65	„
Right-angle to Platberg	=	142501·00	„
Ramah to Platberg	=	566124·32	„

Ramah to Platberg. Total length	=	107·22	miles.
Ramah to Orange River	=	3·00	„
Platberg to Vaal River	=	12·00	„

Hence total length of boundary line is = 122·22 miles.

52 triangles were calculated, irrespective of the sections of base line and calculations of direction of boundary line.

71 points on the boundary line in addition were calculated in the minor triangles.

Appendix E.

Co-ordinates.—Whilst calculating the triangulation, each trigonometrical station was referred to a meridian line passing through the south end of base at Fredericksberg, and to a great circle cutting this meridian at right angles. This was worked out by general geometry, and as it was done for the purpose of plotting the survey it was not considered necessary to make any allowance for the difference between a great circle and a parallel of latitude, for the short distance that the survey extended on either side of the meridian. The convergency of the meridians between the two base lines only amounted to about nine minutes, which is quite inappreciable on a survey of 120 miles, from north to south, plotted to a scale of three miles to one inch.

Appendix F.

Many points on the boundary line having been fixed by the triangulation, and the co-ordinates of these points being known, the direction of the line was calculated therefrom, the true azimuthal bearing having been obtained for the sides in the triangulation, at the northern and southern extremities. The results were much closer than I anticipated. For example, by co-ordinates, the angle at Tarantaal Kop, between David's Graf and Platberg, was calculated to be 161° 50′ 1·3″, while the same angle observed was 161° 49′ 57·6″ error 3.7″.

Again at Tarantaal Kop, between the right-angle and David's Graf, the angle was calculated to amount to 81° 47′ 29·3″, while the same angle observed, gave 81° 47′ 27·7″, error 1·6″.

The difficulty of course lay in setting off a mean bearing, and to ensure this we reversed the system used in observing, and when laying off a line, put the staff holder into position a great number of times from independent readings; these points were marked on the ground, and the mean position of the staff was worked out from among them. This practical method was evidently susceptible of great accuracy, for lines set off, and continued in this method for 40 to 60 miles, invariably came to within the radius of the beacon, the limit of error not exceeding three to four feet; whereas, had better instruments been used, and the line set off with only one trial, no matter how accurate it may have been made, I have no doubt that the error would have been greater.

In tracing these lines signals were flashed at long distances, up to 35 miles, with pieces of mirror about four inches in diameter, which could be easily worked after a few trials; large flags were also used at this distance, but they could not always be distinguished.

The fixing of the right-angle on the ground, though so simple a matter on paper, was a delicate operation on a line which had first to be correctly traced for a distance of 60 miles, and then have a right-angle thrown off it to the pile at Tarantaal Kop.

After having laid down the line from Platberg to David's Graf, and having calculated the angle at Tarantaal Kop in the proposed right-angled triangle, an instrument (10-inch theodolite) was set up at Tarantaal Kop, and another (12-inch theodolite) on the line Platberg to David's Graf; after a few trials which occupied many hours (for the country was much covered with brushwood), the actual position of the apex of the right-angle was fixed to within a limit of radius of three feet; we then obtained a mean of the observations from Tarantaal Kop, and its cutting on the corrected line from David's Graf to Platburg, and fixed the intersection.

Appendix G.

The piles for trigonometrical stations differed in height, according to the positions and distances from which they had to be observed. They were generally made of large stones, which two or three men could just lift and pile on, picked up from the rocky summits on which the piles were generally placed. They were now and then shattered by lightning, and at one station the pile was pulled down by baboons more than once, but otherwise they stand well, and will last for many years. When practicable, the sites of farm beacons, which are usually prominently situated, were selected both because they thus would be preserved intact and in order to avoid confusion. Additional beacons would run the risk of being removed by farmers. The jumping* of farm beacons in these parts had become an act of the past. They were usually about eight feet in height, with a base equal to half the height, say four to five feet.

The piles or beacons for the boundary line, were constructed according to the position and circumstances. In out of the way, wild places, they were usually placed at a distance of three miles

* Vide Deut. 27, 17.

and were made large and very strong, so that there would be a difficulty in removing them, and so that they would not run the risk of being pushed over by wild animals; those, on the other hand, in cultivated parts and near Kimberley, were placed at intervals of one mile, and were made of small size, not more than eight feet in height. They were there placed close together, so that in any case of disputed jurisdiction there would be no difficulty in ascertaining with the eye, the exact boundary line.

Some of the most important beacons, such as Tarantaal Kop Scholtz Nek, Right-angle, David's Graf, and Platberg, were erected from 13 to 16 feet in height (in some instances of large boulders), while in other cases they averaged 11 to 12 feet in height. The base was about equal to the height.

There are 70 beacons laid down, 20 between the Orange River and David's Graf; 20 from thence to Tarantaal Kop, and 30 from thence to the Vaal River. From Scholtz Dam to Tarantaal Kop there are 15 visible in one line, and the slopes of the ground so run, that they look like a line cut through the Veldt, and are so beautifully regular, that when the Boers first saw the line on the inspection, one of them exclaimed, "Allemachti! The Queen's Secretary of State could not have laid it out better if he had come here himself to do it." Chorus "Allemachti, Lord Carnarvon himself could not have done it better."

The absolute and relative heights of the various points on the boundary line were not required, and as the early demarcation of the line was strongly urged, it was not possible to devote any time to this subject.

Aneroid observations were however taken daily in camp, at most of the trigonometrical stations, and at various points on line, but as the weather was very unsettled while the work was in progress, no great weight can be attached to the observations.

There was no certainty as to the absolute height of any particular point on this elevated table land, but after a comparison of various results I have taken the following as approaching accuracy.

Market place, Kimberley, 4000 feet above mean sea level.
Volksraad House, Bloemfontein, 4350 " " "

With these data it may be said that the boundary line commences at a height of about 3950 feet on the Vaal River and terminates at a height of about 3350 feet on the Orange River, that the highest points passed were at Platberg, 4200 feet, Scholtz 3800 feet, and that the greatest variation between any two points, did not exceed 300 to 400 feet.

I give a list of some of the most important heights attached, but as levels of many points in Griqua-Land have recently been taken more accurately with a spirit level I do not attach much importance to these results :—

Heights.

Market-place, Kimberley ...	4000	feet above mean	sea level.
Orange River, Lang Ford ...	3350	"	"
Witputts	3650	"	"
Belmont	3800	"	"
Honings nest Kloof	4000	"	"
Junction Drift, Modder River,	3600	"	"
Marsfontein	3750	"	"
Scholtz	3800	"	"
Erasmus (near Warren Town)	3950	"	"
Blignauds' Pont, Vaal River	3950	"	"
Fredericksberg (base) ...	3700	"	"
Fredericksberg, (summit) ...	4490	"	"

Appendix H.

Fixation of points.—Our first duty was to inspect the line of proposed frontier, and to settle the position (on the ground) of the points named in the Memorandum of Agreement, at the same time verifying the eastern boundaries of the Diamond Fields, which were to be kept within the limits of the boundary.

In this matter there was no great difficulty. *Ramah* we fixed at a beacon at the eye of the fontein, which appears to have been laid down by Surveyor Mr. de Kok in 1859, and subsequently used as a trigonometrical station by Mr. Orpen. I have no doubt whatever, that this point was the *Ramah* boundary of former days, for the remains of the old village were close at hand, and the gallows.

David's Graf we fixed at a short distance to the east of the point laid down in Mr. de Villiers plan, at a beacon placed near the drift (ford) on the southern side of the Riet River, marking, as far as we could ascertain, the northern termination of the line laid down in 1859 by Mr. de Kok, about three miles above the junction of the Riet and Modder Rivers. I have little doubt that this was the place where David was buried, as the Griqua graveyard was just the other side of the ford; but we were certain it was the David's Graf of Mr. de Kok, from which he traced his line to Ramah, and as all the farms along the line abut on it, it was of great importance to the farmers that we should agree upon a line that should not cut off pieces of these farms. We could not, however, avoid a difficulty due to Mr. de Kok's line being crooked, which I have referred to when speaking of tracing the line.

Tarantaal Kop was found to differ in shape from that depicted in Mr. de Villiers' plan, the position being more north and south than east and west; we had, however, no difficulty in agreeing on this point.

Platberg we have taken as a beacon in the centre of the flat hill, (as shown in Mr. de Villiers' plan) which had previously been used as a trigonometrical point both by Mr. Orpen and Mr. de Villiers.

By thus taking old points we prevented confusion arising from a multiplication of beacons, and facilitated the connection of our work with the former triangulation. It is mentioned in the Memorandum of Agreement that the boundary line shall include "the whole of the places known as the Diamond Fields" and it was at first uncertain what this term might include, it being argued by some that it meant a distance of three miles from the actual mines.

On laying down this line it was found to cut about two miles to the east of the edge of Dutoits pan mine, and I considered that it was not necessary to raise the question, as a few hundred yards more would be of little use in stopping the illicit diamond traffic. This would require a limit or distance of at least ten miles for the boundary line.

In settling these points I kept in view the fact that Lord Carnarvon attached quite as much importance to arriving at a settlement which should be final and satisfactory to both sides, as to the actual precision of the survey work, and I found no occasion to exercise the discretionary power accorded to me of making such concessions in minor matters, without sacrificing material points, as might seem necessary in order to prevent disagreement or controversy in the future.

The farms of Erasmus and Joubert had already been surveyed and the beacons were known, we therefore had only to verify them on the ground with the plans from Bloemfontein, to bring the beacons into our triangulation and to find the intersections of the boundary line with the lines bounding the farms. These farms were of the ordinary size in this country, from three to five miles across.

Mr. Surveyor de Kok had in 1852 laid down a boundary line separating the lands of Waterboer from those of Adam Kok, starting from an assumed David's Graf to the eye of the fontein at Ramah, but his position of David's Graf had been called in question.

The farmers had received their respective grants of land from Waterboer or Adam Kok, with this line as their limit, and therefore we considered it a matter of the gravest importance to the land-owners that this line should continue to remain the boundary if practicable; we therefore agreed to accept De Kok's position of David's Graf, although Mr. de Villiers' point was somewhat further to the west in his plan.

When we came to lay down the line we found that De Kok's line was not straight and lay some half-a-mile out of the line in the centre; this introduced a very difficult question with regard to the farm boundaries. They had bought them as running up to a straight line between David's Graf and Ramah, but this line some 25 years before had been traced crookedly.

The question soon arose whether they should continue to hold as before, in which case some of the Orange Free State farmers would have pieces of their farms in British territory, or whether the boundaries should be rectified, by which process some of the farmers would gain or lose several thousand acres.

Practically it was a legal question, and one which could only be tried in Griqua-Land West, because De Kok's line overlapped to the west.

The difficulty however only existed to any great extent in about three farms, and eventually it was got over by certain farmers buying the land on both sides of the line.

Conclusion.—I must not omit to allude to the cordial co-operation of my colleague and friend Mr. Jos. de Villiers, throughout the work, and to the ready assistance of President Brand, of the Orange Free State, and Major Lanyon, Administrator of Griqua-Land West, and of his officials with whom I came in contact.

I have a most pleasant recollection of the Boers about the boundary line who, though they viewed with the greatest disfavour the incorporation of their lands into British territory, were always on the most friendly terms with our survey parties, and with many of whom I have formed lasting friendships. Finally I must record the good services of the N.-C.O's., R.E., and especially of Serjeant F. Kennedy, who carried out his duties so well and cheerfully under very trying circumstances.

C. W.

The heavy bullet materially increases the relative weight of the ammunition to be carried, but has the advantage of giving relatively high velocities and low trajectories at the longer ranges.

Lieutenant Indra considers that in any future rifle the calibre will be reduced to ·3937 inches, the bullet being lengthened to $2\frac{3}{4}$ calibres with a weight of ·8457 ounces and a charge of ·1741 ounces. He gives tables proving that these data give the best theoretical results as regards flatness of trajectory at all ranges.

It is probable that if a new rifle is introduced into the English services, approximation will be made to these proportions of charge, calibre and projectile.

Remarks on Table II.

In examining this table in conjunction with Table I., it will easily be seen that the variations are mainly due to the ratio of the weights of charge and bullet, and to the length of the latter in calibres.

The greater the velocity the flatter the trajectory.

To gain maximum initial velocity and consequent flatness of trajectory at short ranges, it is necessary that the charge should be large in proportion to the weight of the bullet.

To retain maximum velocity and flatness of trajectory at long ranges, it is necessary that the resistance of the air should be at a minimum, and this will mainly depend on the proportion of the weight of the bullet to its area of cross-section, which is very nearly identical with its length in calibres.

Remarks on Table III.

In this table the various proportions are so arranged as to be easily compared, and to illustrate the remarks made on Table II.

It will be seen that, of the new rifles, the "Gras" of France, with the largest proportional weight of charge to bullet (·21), has also the highest initial velocity (1430), and that the "Martini-Henry" of England, while having the smallest proportional weight of charge to bullet (·1768), has also the lowest initial velocity (1276).

The great weight of the English bullet, and its consequent greater relative length in calibres (2.7) enables it to retain its velocity for a longer period, and thus although the trajectory of its flight is relatively high up to 600 paces, at the longer ranges it exceeds all others in velocity, consequent flatness of trajectory, and extent of dangerous zone.

There is no doubt that by lessening the calibre and consequent weight of bullet, while retaining the present charge and relative length of bullet, thus greatly increasing the proportions of charge to bullet; and also, if thought necessary, at the same time lengthening the barrel; a rifle might be produced which should combine all the good points of both the English and Continental types. Whether the resulting flatness of trajectory at short ranges, reduction of weight of ammunition, and greater reach of bayonet, would compensate for the great expense, inconvenience, and temporary loss of efficiency caused by an entire change of arms and ammunition throughout the services, seems extremely doubtful.

In the meantime we may be thankful that we have already a thoroughly efficient weapon.

H. T.

TABLE I.

DESCRIPTIVE DATA AS TO MODERN RIFLES.

		England.	Austria.	Germany.	France.	Russia.	Italy.	Spain.	Switzerland	Converted Arms.		
										Austria.	Russia.	England.
		Martini-Henry.	Werndl. 1873	Mauser. 1871.	Gras. 1874.	Berdan. II.	Vetterli.	Remington.	Vetterli repeater.	Wanzl.	Krnka.	Snider Enfield.
Calibre	in.	·450	·433	·433	·433	·420	·409	·433	·409	·547	·600	·577
Grooves. Number		7	6	4	4	6	4	6	4	4	4	3
Grooves. Form		in heptagonal form.	rectangular concentric.	rectangular concentric.	rectangular concentric.	rectangular concentric.	rectangular concentric.	rectangular concentric.	rectangular concentric.	rectangular concentric.	rectangular concentric.	...
Grooves. Depth	in.	·0073	·0079	·0118	·0118	·0106	·0098	·0079	·0098	·0079	·0149	...
Grooves. Length of one turn	ins.	22·0	28·50	21·65	21·65	21.65	25·98	25·59	25·98	82·67	52·75	78·0
										opening Tabatiere.		
Mechanism. Closing		block.	plug.	bolt.	bolt.	bolt.	bolt.	block.	bolt.	upwards.	to left.	to right.
Mechanism. Striking		spiral spring.	flat spring.	spiral spring.	spiral spring.	spiral spring.	spiral spring.	direct.	spiral spring.	lock.	lock.	lock.
Length of arm	ins.	48·12	50·39	52·36	51·38	53·54	52·95	51·18	51·18	52·75	53·50	55·0
Weight of arm	lbs.	8·818	9·193	9·920	9·259	9·590	9·59	8·983	10·36	9·369	9·942	9·0
Bullet. Form. Body		smooth.	smooth.	smooth.	smooth.	smooth.	grooved.	grooved.	grooved.	grooved.	grooved.	...
Bullet. Form. Head		semi-oval.	ogival.	ogival.	conical,	hemi-spherical.	hemi-spherical.	hemi-spherical.	hemi-spherical.	ogival.	ogival.	...
Bullet. Length in calibres		2.7	2·5	2·5	2·5	2·5	2·4	2·5	2·45	1·5	1·87	...
Bullet. Diameter	in.	·450	·433	·433	·425 ·433	·425	·425	·449	·425	·563	·598	...
Bullet. Weight	oz.	1.097	·845	·880	·880	·845	·718	·883	·718	1·045	1·297	1·097
Action of the grooves		paper wrapper set-up and compression.	paper wrapper, set-up and compression.	paper wrapper, set-up and compression.	paper wrapper, set-up and compression.	paper wrapper, set-up and compression.	set-up and expansion.	set-up and compression.	set-up and expansion.	set-up.	set-up and expansion.	...
Charge	oz.	·194	·175	·175	·183	·175	·140	·175	·131	·153	·177	·160
Weight of cartridge,	oz	1·802	1·487	1·501	1·533	1·375	1·207	1·449	1·067	1·480	1·926	1·606
Muzzle velocity, feet per second		1276	1437	1410	1430	1430	1427	1410	1417	1240	1072	
Sighted up to	yds	1400	1750	1800	2000	1250	1100	1100	1100	750	670	950

NOTE.—The various rifles whose data are given above can be seen at the *United Service Institution, Whitehall Yard.*

TABLE III.

COMPARATIVE DATA AS TO MODERN RIFLES.

Country.	Rifle.	Proportions of weights of charge and bullet.	Initial velocity, feet per second.	Length of bullet in calibres.	Proportions of initial velocity remaining at								Relative proportion of weight of bullet to calibre.
					Height of Trajectory.	Paces, 600.	Height of Trajectory.	Paces, 1200.	Height of Trajectory.	Paces, 1800.	Height of Trajectory.	Paces, 2400.	
England.	Martini-Henry.	·1768	1276	2·7	9·912	·6724	42·446	·5219	116·075	·4866	243·748	·4584	2·437
Austria.	Werndl, 1873.	·2071	1430	2·5	7·933	·5231	49·01	·3923	147·454	·3636	337·483	·3370	1·951
Germany.	Mauser, 1871.	·2	1410	2·5	,,	·5447	,,	·4241	,,	·3794	,,	·3496	2·032
France.	Gras, 1874.	·21	1430	2·5	,,	·5301	,,	·4251	,,	·3832	,,	·3531	2·032
Russia.	Berdan II.	·208	1430	2·5	,,	·5384	,,	·4042	,,	·3727	,,	·3426	2·012
Italy.	Vetterli.	·196	1427	2·4	,,	·5024	,,	·3672	,,	·3405	,,	·3111	1·755
Spain.	Remington.	·1992	1410	2·5	,,	·5447	,,	·4241	,,	·3794	,,	·3496	2·039
Switzerland.	Vetterli repeater.	·1838	1417	2·45	,,	·5017	,,	·3676	,,	·3401	,,	·3112	1·755
Austria.	Converted arms. Wanzl.	·1464	1240	1·5									
Russia.	Converted arms. Krnka.	·1365	1073	1·87									
England.	Converted arms. Snider Enfield.	·1458											

PAPER VIII.

MEMORANDUM ON OPERATIONS OF THE

BENGAL SAPPERS AND MINERS,

AT

GANDAMAK & JAGDALAK, AFGHANISTAN,

In November and December, 1879.

BY LIEUT.-COLONEL E. T. THACKERAY, V.C., R.E.

THE 2nd and 6th Companies of Sappers arrived at Safed Sang from Jalalabad on the 30th October, 1879, and were attached to the 1st Brigade, 2nd Division, Khaibar Field Force, under command of Brigadier-General C. Gough, C.B., V.C.

On the 2nd November, orders were received for these two companies to accompany a column under command of Major-General Bright, C.B., which marched from Safed Sang on the 3rd November, for the purpose of clearing the road and opening out communication with a force marching at the same time from Kabul, under command of Brigadier-General Macpherson, C.B., V.C.

The 6th Company, under command of Lieut. Stafford, R.E., with Lieuts. Stanton and Randolph, R.E., had previously been employed in putting up the line of telegraph from Landi Kotal to Safed Sang.

The supply of the articles of warm clothing, shewn in Appendix A, had been previously authorised by the Government of India for British and Indian Troops, and these were served to the men as received.

The force under Major-General Bright, C.B., that marched from Safed Sang on the morning of November 3rd, was composed as follows:

Guide Cavalry.
10th Bengal Lancers.
A Mountain Battery.
2nd and 6th Companies, Sappers.
24th Panjab Infantry.
1 Regiment of Guides (Infantry).

Major-General Bright, C.B., and his Staff accompanied the column, and also Brigadier-General C. Gough, C.B., V.C., commanding the 1st Brigade. Colonel Limond, R.E., was Commanding Royal Engineer. The Officers of Royal Engineers attached to the Sappers were Major Thackeray, V.C., R.E., commanding; Lieuts. Campbell, Stafford and Stanton, R.E.

The force was in light marching order, and was rationed for 7 days. It reached Surkh-ab Pul on November 4th, Jagdalak on the 5th, Kata Sang on the 6th. No opposition was met with except a few shots that were fired at the rear guard between Jagdalak Kotal and Peiwar. On arriving at Kata Sang, a meeting took place between General Bright and Brigadier-General Macpherson, who had marched from Kabul without opposition.

Posts having been established at Pezwan, Jagdalak Fort, and Jagdalak Kotal, the force under General Bright returned to Safed Sang, reaching that place on the 9th November.

A portion of the force marched through the celebrated Pari Dara defile. This pass is flanked on both sides by precipitous rocks of great height. The width in the narrowest place was not more than 9 or 10 feet, and only part sufficient to allow of the passage of a camel with a full load.

During these operations, the 2nd Company (Sappers) was employed in improving and widening the road and making it passable for guns.

At Kata Sang tanks were made in the bed of the streams for the horses and camels to water.

The 6th Company put up the line of telegraph from Safed Sang to Pezwan. The line was a single one carried for the greater part of the distance on bamboo poles. The hills being very steep, the work entailed much fatigue on the men, and was done in a most creditable manner under Lieut. Stafford, R.E.

Of the 6th Company all the officers suffered at different times from fever caused by exposure.

On the 8th November, the Head Quarters and 5th Company of Sappers arrived at Pezwan from Roorkee, and returned to Safed Sang on the following day with General Bright's column. On the return of the column, orders were received for the 2nd Company, Sappers, to be left at Jagdalak Fort, to strengthen the post at that place and also at Jagdalak Kotal. The 6th Company was also left at Pezwan to make a fortified post, and to improve the road two miles beyond Pezwan, where there is a steep and rough defile. This portion of the road was subsequently greatly improved, the rocks being blasted with gunpowder and guncotton, under Lieut. Stafford's superintendence.

On the 13th November, orders were received for the main portion of General Gough's Brigade to march from Safed Sang to Gandamak, three miles, where it was proposed to form a permanent camp for the winter. From this date to the 14th December, the Head Quarters and 5th Company remained in camp at Gandamak. The 5th Company under command of Lieut. Hill, R.E., and all available men were employed in demolishing the ruins of the old cantonment, and rebuilding three of the old lines of huts that had remained since the former occupation of Gandamak by the British in 1842. The walls were built of rough stone boulders laid in mud. The roofs were constructed of poles or *bullees*, placed 5 or 6 inches apart, supported upon horizontal beams, which again rested upon vertical uprights let into the ground. The roof covering consisted of grass mats over which 6 inches of earth was laid and well rammed. The floor consisted of rammed earth, and, being from two to three feet below the level of the ground, the huts formed a complete and comfortable shelter from the cold winds and dust storms, which blew with great intensity.

Dust storms at this season of the year seem to be a prevailing feature of the climate of this part of Afghanistan, continuing sometimes for three days without interruption. During the height of these storms, the men were prevented from working, their eyes becoming filled with sharp sand. At Jalalabad, the late Amir Shir Ali had constructed underground pits or caves to shelter his troops from the dust storms.

The Telegraph Office at Gandamak was worked by a Serjeant of Sappers under the superintendence of Lieut. Blunt, R.E. Conductor White, in charge of the photographic department, took some views of the country, but his work was interrupted owing to a telegram from Lieut.-General Sir F. Roberts from Kabul, directing the photographic equipment to be sent to Kabul, in order that views might be taken of the Bala Hissar and the Sherpur cantonment.

An old mill had been formerly used by the Afghans in the river that flows by Safed Sang. This had been repaired and provided with turbines and an improved system of water sluices, under the superintendence of Surgeon-Major Amesbury, the Officer in Medical charge of the Corps.

On the return of British Troops in November, the mill was found in good repair, and had not been injured by the Afghans during our temporary evacuation of the country between the months of June and November, 1879. This mill was now completed with the sanction of the Brigadier-General. Three mill stones were worked daily; the whole being placed under the charge of an intelligent Sapper. Large quantities of grain, barley, and other cereals, were ground for the Cavalry and Horse Artillery, and for the Commissariat Department, and a considerable saving of manual labour was effected. The erection of the mill was chiefly due to the energy and inventive skill of Dr. Amesbury.

Besides the construction of the huts, before mentioned, parties of Sappers under an Engineer Officer were daily employed, under the orders of the Commanding Royal Engineer, in assisting the Field Engineers in laying out the lines for the different Corps at Gandamak, for whom rows of huts were commenced, and also in laying out and tracing the profiles for a large fort, distant about half-a-mile from the Camp.

The walls of this fort were constructed entirely of stone boulders, laid dry. The shape of this fort was rectangular, with semi-circular bastions in the centre of the two larger faces. In front of the entrance was a ditch, which it was proposed to complete with a drawbridge. The interior of the fort was laid out in spaces for the Hospitals, Commissariat and Ordnance Stores, &c. Large numbers of Ghilzais and Hazaras were employed daily in building the walls of this fort.

The works that were commenced at Gandamak were all abandoned on the march of the 1st Brigade to Kabul, on the 14th December, orders being then issued for the whole force that remained to be concentrated at Safed Sang. The Officers present with the Sappers at Gandamak during November and December were Major Thackeray, V.C., R.E., Commandant; Captain and Brevet-Major North, R.E., Adjutant and 2nd in Command; Captain Stuart, B.S.C., Interpreter and Quartermaster; Lieuts. Hill, R.E., and Maxwell, R.E.; Surgeon-Major Amesbury in Medical charge.

The weather at this time was cold and bracing, the thermometer at night reading below freezing point. The small water course that flowed through the camp was frozen at night. In the early part of December, the 3rd Company, Sappers, under command of Lieut. Dove, R.E., arrived at Gandamak from Landi Kotal, and proceeded at once to Jagdalak Kotal for the purpose of strengthening the fortified post at that place. The health of the men during their stay at Gandamak continued on the whole to be good, but several men of the companies stationed at Pezwan and Jagdalak suffered from pneumonia and dysentery, and had to be sent to the Corps Hospital which was established at Gandamak. About the end of November, a bugler of the 6th Company was attacked and slightly wounded by a party of Afghans near the camp at Pezwan, while returning from a village, and a few days later a Sapper of the 3rd Company was murdered close to a village, about three miles from Jagdalak Kotal. His body was found two days afterwards, much mutilated. It was afterwards found that the inhabitants of the village were implicated in the murder, and the village was burnt by a detachment of Sappers under command of Major Thackeray, who was accompanied by the Political Officer, Captain Tucker, B.S.C.

From information received by Brigadier-General Gough, and from the fact that the Ghilzai workmen employed on the roads, &c., were deserting in great numbers daily, a rising on their part against us now appeared imminent. The Brigadier-General was also informed by Major-General Bright, Commanding the 2nd Division, that news had been received of severe fighting at Kabul, and that our force had been attacked there by immense numbers of the enemy, and was warned to hold himself in readiness to advance towards Kabul at once, in case of communications being interrupted. In consequence of this intelligence, orders were issued on the 13th December for a force to march towards Kabul on the following morning. The details of this force were as follows:

10th Bengal Lancers ...	130 men.
No. 5 Company, Sappers,	73 ,,
2-9th Foot	487 ,,
4th Gurkhas	375 ,,

The outpost at Pezwan, near the Surkh-ab River, was held by 157 men of the 2nd Gurkhas, 6th Company of Sappers, 4 guns of the Hazara Mountain Battery, 50 men of the 10th Bengal Lancers. At Jagdalak Kotal, there were the 2nd and 3rd Companies of Sappers, and 40 men of the 2nd Gurkhas. Jagdalak Fort was held by 180 men of the 2nd Gurkhas, 2 guns of the Hazara Mountain Battery, and 90 men of the 10th Bengal Lancers.

On the 14th, General Gough marched from Gandamak with the force stated above, reinforcing on that day, Pezwan, by 280 men of the 2-9th Foot, and 187 of the 4th Gurkhas; and Jagdalak Fort by 207 men of the 2-9th Foot, 100 of the 4th Goorkhas, and 130 of the 10th Bengal Lancers. The Officers of Engineers who marched with the force under Brigadier-General Gough from Gandamak, were Major Thackeray, V.C., R.E., commanding the Sappers; Captain and Brevet-Major North, R.E., Adjutant and 2nd in Command; Lieuts. Hill and Maxwell. The Officers told off to remain at Safed Sang, were Captain Stuart, B.S.C., Interpreter and Quartermaster; Lieut. Blunt, R.E., in charge of the Workshops and Telegraphy; Dr. Amesbury, in charge of the Corps Hospital.

The 24th Panjab N.I., and 3 Companies of the 51st Light Infantry, which had been ordered up from Jalalabad, and I Battery, A Brigade, R.H.A., were left at Safed Sang. General Gough with his staff, and two guns of the Hazara Mountain Battery, which he took with him from Pezwan, arrived at Jagdalak Fort on the evening of Dec. 14th. The General made a minute inspection of the post at Jagdalak Kotal, which is situated 150 yards on the west of the road to Kabul, and distant about 4 miles from Jagdalak Fort. Major Thackeray was directed to remain in command of this post, to strengthen the defences, and to make all necessary arrangements for holding the post. This post is situated at a height of 6,300 feet above the level of the sea, at the highest point of the road, on the west side of the Siyah Koh range of hills. The road slopes by a gradual descent towards Pezwan, but on the other side towards Jagdalak Fort there is a steep defile commanded by hills on both sides.

On arriving at Jagdalak Fort, the Political Officer received positive assurance that a large force of Ghilzais under Asmatullah Khan was within 5 miles, and that General Gough's force would be attacked on the following night.

The ruined fort at Jagdalak, in which the troops were encamped, consists of two walled enclosures on a hill about 120 feet high, on the west of the river. General Gough at once set his troops to work to strengthen and repair the walls, and to raise stone breastworks (or *sangas*) on the two adjoining hills which were occupied at night by picquets of the 2nd Gurkhas. All the horses and transport animals were brought inside the walled enclosure, and on arrival of the detachments, which were left the previous evening at Pezwan, the troops were assigned their different positions in event of a night attack.

Early on the morning of the 15th December, it was reported to Major Thackeray, commanding at Jagdalak Kotal, that shots were heard on the road to Pezwan, about 3 miles from the Kotal, and soon afterwards a sowar of the 10th Bengal Lancers, was seen riding slowly up the ascent to the Kotal, leading a riderless horse. The man was unable to dismount on arriving at the Kotal, and was lifted from his horse, when it appeared that he had been shot through the ankle. He reported that he had formed one of a party of four sowars of the 10th Lancers, proceeding to Kabul with despatches, and a case of chloroform, which was urgently required there. On arriving at the broken nullah, about three miles from the Kotal, they were fired upon by a party of the enemy concealed behind rocks close to the road. One of his comrades was killed. He was shot in the leg, the bullet also passing through the body of his horse. Although badly wounded, he stayed behind to try to render assistance to his comrade. He fired 5 or 6 shots with his carbine, and it was not until he found that further resistance would be useless, that he seized his comrade's horse, and arms, &c., and rode off. The body of the sowar who was killed was afterwards brought in. Major Thackeray, with a small party of Lancers, who had come over from Jagdalak Fort, proceeded at once to the spot where the men had been fired upon, and there met another detachment of Lancers under Captain Seymour Barrow, who had ridden over from Pezwan. The Lancers captured two men; and a picquet of the 2nd Gurkhas, near the spot, caught another man heavily armed, and his jezail appearing to have been recently fired. These men were afterwards tried by a Military Commission. The man on whom arms were found, was sentenced to death, but his sentence was remitted by order of the Brigadier-General, the Political Officer having represented that he was in the employ of a friendly Khan who accompanied the force. During the 15th, the earthworks at Jagdalak Kotal were strengthened, and traverses were put up across the banquettes, at distances of from 15 to 25 feet, measured along the interior slopes. The traverses were made with stout planks, 16 to 18 feet long, 1 foot wide, and $1\frac{1}{2}$ to 2″ thick, placed on end, and let into the earth. The planks happened to be on the spot, having been brought to the spot by the Ghilzai workmen before they deserted, for the purpose of roofing in a temporary hut, which was being built for a hospital. As an attack seemed highly probable, water tanks were also constructed by digging excavations about 6 feet long, and 2 to 3 feet deep, and covering the holes with waterproof sheets. A larger tank was also made, but was not found to answer as well as the smaller ones, as leakage took place at the junction of the sheets. The 2nd and 3rd Companies, Sappers, were employed all day at these works. In the evening, the detachments from Pezwan, under command of Colonel Daunt, 9th Regiment, including the 5th Company, Sappers, with Brevet-Major North, and Lieuts. Hill and Maxwell, arrived at the Kotal, and proceeded at once to Jagdalak Fort.

The rear guard was fired upon by the enemy shortly after leaving the Kotal, and a detachment of the 10th Lancers was sent out from Jagdalak Fort to its assistance. By order of the Brigadier-General, the Company of the 2nd Gurkhas at the Kotal was relieved by a Company of the 4th Gurkhas from Pezwan, the former company marching back to Pezwan. Meanwhile at Jagdalak Fort, the work of strengthening the ruined walls went on all day. In the upper enclosure were quartered the 10th Lancers, 2nd Gurkhas, and the Mountain Battery, and here also were placed the tents of the General and his Staff. In the lower enclosure, all the remaining troops, and the transport animals. The force at Jagdalak Fort was then compared as follows:

9th Regiment	500 men.
2nd Gurkhas	180 ,,
4th Gurkhas	385 ,,
Hazara Mountain Battery	4 guns.
5th Company, Sappers	73 men.
10th Bengal Lancers	210 ,,

Altogether nearly 1400 men.

On the glacis facing the direction from which the Ghilzais were expected to approach, wire entanglements were placed. Towards evening, intelligence was brought in that the enemy were approaching, and just before sunset, a body of about 50 or 60 armed men could be clearly seen on the top of a hill about 1200 feet above the level of the valley, and distant about 2500 yards from the fort. Preparations to resist a night attack were then made. The 9th Regiment and 5th Company, Sappers, manned the three walls of the lower enclosure, having with them 2 mountain guns, while the upper enclosure on the east side was guarded by the mountain battery; on the south by the 10th Bengal Lancers, and on the west by the Gurkhas. Soon after sunset, the enemy began to move down the hill with the object of cutting off some of the convoy which had not yet arrived. This movement was frustrated by a strong party of Lancers under Major England, which brought up the rear. By 6.30 p.m. all were safe in camp, and the troops placed in position. Almost all the tents were struck and fires put out.

The enemy commenced firing at 1000 yards distance, and becoming bolder at having no response, crept up within 500 or 600 yards, and commenced firing at the fort. One party of them got round to the south and ascended a small hill about 400 yards from the fort, from which they were quickly dislodged by a volley from the Gurkha picquet. Firing continued until 10 p.m., and then ceased till dawn. The lancers made an excellent *chevaux de frise* with their lances on the southern parapet, and each man lay in readiness under cover. At Pezwan, and at Jagdalak Kotal, the night passed off quietly, and no attacks were made on these posts.

At Jagdalak Fort, on the morning of the 16th, the enemy was found to have retreated to the hill on the east of the camp, and was engaged in throwing up breastworks, apparently with the expectation of our attacking them. The troops were employed during the day in improving the defences, and took no notice of the enemy beyond posting two outlying picquets, which exchanged a few shots with them at long distances. It was believed that the attack of the previous evening was not by Asmatullah's men, but from those commanded by Mamula Khan, Chief of the Langa Khels, who had with him Abdul Kuram Khan, who commanded the Afghan forces at Charasiab.

The strength of Asmatullah's force was reported to be about 5,000 men. At this time there was no telegraphic communication with Kabul, the wire having been cut in many places, and large portions carried away. Heliograph signalling was carried on between Jagdalak Fort and the Kotal and Pezwan. The latest news from Sir F. Roberts was that he hoped for the speedy arrival of reinforcements, and that the troops were entrenching themselves at Sherpur. During the day (16th) a strong breastwork was thrown up, 100 yards in front of the east side of Jagdalak Fort, to be occupied at night by a strong picquet, to check any rush on this side. To protect the working party, half a company of the 9th were sent out to drive the enemy from the hill side, from which they had commenced firing in the early morning, and getting within a range of 500 yards, succeeded in killing four, causing the remainder to retreat to their *sangas* at the top of the hill.

While the working party was digging, a number of rupees, bearing date 1835, were found. Some were Government rupees, some belonged to Native States, and a few were of Kabul, all were bright as if fresh from the mint. Towards evening the covering party of the 9th was withdrawn, and two small mines of guncotton were placed in the north east glacis.

At Jagdalak Kotal, the earthworks were further strengthened, and the ditch deepened and improved. A signalling post was established at the top of the high hill on the east of the road, and an Engineer Officer was told off daily to proceed to the post, to conduct the signalling operations. Owing to the hills that intervened between the Kotal and the Fort, it was impossible to signal direct between the two stations, so that messages received from Pezwan had to be sent to Signallers' Hill, from whence they were flashed to Jagdalak Fort. Another signalling post was established on the west of the road, about a mile distant from Jagdalak Kotal.

Early in the morning of December 17th, Major Thackeray, taking with him the 3rd Company of Sappers, with Lieuts. Dove and Randolph, R E., made a reconnaissance of the ground to the east of the road leading from the Kotal to Pezwan, with the object of ascertaining if it would be possible to construct a better road than the existing one, so as to obviate the necessity of the convoys passing through the defiles and broken ground between the Kotal and Pezwan, in which the enemy concealed themselves for the purpose of attacking the convoys. Lieut. Campbell, R.E. remained in command at the Kotal with the 2nd Company, Sappers, and a company of the 4th Gurkhas. The reconnoitring party proceeded about three miles along a path that runs near the foot of the high range of hills, that stretches in a northerly direction nearly parallel to the road. This path was found to be much cut up by deep ravines, and it being evident that no advantage would be gained by adopting this line for a road, the party was ordered to return to the Kotal. At this time, about 11 a.m., the enemy's infantry with some mounted men, was observed in great force on the west of the road, posted among the ravines where the convoy had been attacked, and at the same time a column of our troops was seen to be advancing from the Kotal, with the object of attacking them. On arriving at the road, the reconnoitring party was met by the latter column, which had been sent out from Jagdalak Fort in the morning by Brigadier-General Gough, for the purpose of escorting the mails, and opening out the road.

Major Thackeray placed the 3rd Company, Sappers, at the disposal of the Officer Commanding the Force. An official report of the action that ensued was given in Brigadier-General Gough's despatch, dated, Kabul, Dec. 26th, and published in the *London*

Gazette, which it is unnecessary here to recapitulate. The 3rd Company, Sappers, under command of Lieut. Dove, R.E., performed excellent service during the action, as skirmishers. The casualties on our side were very few. One man of the 9th was badly wounded in the neck, and a sepoy of the Gurkhas was badly wounded. Considering the closeness of the range from which the enemy fired, the small loss on our side was very remarkable. Many men of the enemy were seen to fall. They were accompanied with banners and tom-toms, and shouted "Kafir" as our men advanced to the attack. While returning to the Kotal, the Political Officer, Captain Tucker, informed Major Thackeray that he had received information that the inhabitants of a village situated about three miles from the Kotal to the west of the road, were implicated in the murder of the Sapper sepoy, that had taken place a few days previously. The Brigadier-General having authorised the destruction of the village, Major Thakeray, accompanied by the Political Officer, and taking with him the 2nd Company, Sappers, under Lieut. Campbell, R.E., marched to the village along a difficult mountain path. On arriving at the top of a hill that looked down on the village, some of the enemy were observed on another high hill on the opposite side of the village. Leaving half the company on the crest of the hill to act as a reserve, Major Thackeray, with Captain Tucker, who kindly consented to accompany the party, and Lieut. Campbell, R.E., with the right half of the company, descended the hill which was very steep, and covered with large stone boulders and brushwood. The huts were set on fire as rapidly as possible, and the party returned to the ridge where Lieut. Gordon was posted. There was no time to be lost as it was becoming dusk and the enemy appeared to be coming down from their side. The village was completely burnt, as well as a large quantity of straw and fodder, which could not be carried away. The party arrived at the Kotal about 7 p.m. About 9 p.m. the enemy made a night attack on the post, chiefly from the east side. They kept up a smart fire, but the night being dark their aim was high, the only effect of their fire being that a few tents and tent poles were struck. The Sappers and the detachment of the 4th Gurkhas under Lieut. Bolton manned the walls, and returned the fire from one face only, the remainder keeping in reserve; and the enemy finding that nothing was to be gained, drew off at about 11 p.m. with the loss of some of their men.

December 18th at Jagdalak Kotal was spent in improving the defences and completing the wooden traverses which had proved of great service in the last night's attack.

The trench on the west side of the post was also completed. The larger water tank was completed. The enemy shewed in some force on Signallers' Hill, but this did not interfere with the usual day signalling as the party went out to the post at the west side of the Kotal. At night the surrounding hills were lit up by the enemy's fires. These fires which were made with dry wood and bushes, seem to have been lit partly for warmth and cooking purposes, but chiefly with the object of deceiving us as to the enemy's numbers. From the large numbers of fires, and from their close proximity to one another, it is doubtful if parties of the enemy could have been posted at each fire. At Jagdalak Fort, the work of improving the defences was continued. The work done on the two previous days had greatly strengthened the position. It was stated that a mullah (priest) of Ghazni, by name Maski Alam, had been inciting Asmatullah to a religious war against the infidels. This mullah was mainly instrumental in inciting the attacks, both at Kabul and Jagdalak. There was some shooting on our side, apparently with success, as the enemy almost entirely withdrew from the higher hills that commanded the position, and confined himself to annoying and interrupting the communications between Jagdalak and Pezwan Kotal. During the day, a party under Lieut. Straghan, 9th Foot, was sent out to destroy a village, as a reprisal for some of its inhabitants firing on our troops. Some sharp firing took place, but the village was burnt, and the party returned to camp. All chance of an assault by the enemy on the position at Jagdalak Fort was now rendered futile, the position having been thoroughly strengthened, and outworks thrown up by the Sappers under Major North, R.E., and the troops left in camp.

General Charles Gough, on the evening of December 19th, was in a position to push on to Sir Frederick Roberts' support at Kabul, as a very large convoy of prisoners and stores, under the command of Colonel Norman, 24th P.N.I., arrived safely in camp. The whole of the country between Gandamak and Kabul being in arms against us, the convoy business was not carried out without risk and loss of life; for although the natives of the country, whether Ghilzais or Hazaras, will not meet our troops in the open, they were at this time sufficiently numerous to harass very considerably the long string of helpless baggage animals and camp followers, which entailed their protection by a considerable force of all arms. A small column was told off daily to meet all convoys coming from Gandamak, and rarely a day passed without a skirmish, in which, however, our loss as a rule was very trifling. One of the most severe of these skirmishes took place on Dec. 19th. A force, consisting of 200 of the 9th Foot, 100 Gurkhas, 2 mountain guns, and a squadron of the 10th Bengal Lancers, under the command of Major Roberts, 9th Regiment, sallied out from Jagdalak Fort, shortly after sunrise, to meet the large convoy which was expected from Pezwan. As far as the Kotal, this little force met with scarcely any opposition, except at a spot where the pass narrows considerably, which was partially enfiladed from one of the enemy's ranges. Here the fire was hot. Captain Broadfoot brought his guns into action, and after a few rounds, reduced the enemy's fire sufficiently to allow the column to run across without serious loss. On reaching the Kotal, Major Thackeray, commanding the post, warned Major Roberts to prepare for a stout resistance, as large numbers of the enemy had been observed moving down from the higher mountain ridges, with standards. About noon the advanced scouts came into contact with the enemy in the ravines about four miles from the Kotal. A brisk fire was kept up the whole day, the enemy replying with Enfields, Sniders, and Jezails, to the fire of our Henry-Martinis, varied with the louder reports from Broadfoot's guns, which made excellent practice. As Major Roberts' instructions were confined to guarding the main road for the advancing convoy, he confined the operations of the column to holding all the ridges commanding the roadway, until the sound of Colonel Norman's guns announced the arrival of the convoy, with 1200 baggage animals. At one time the enemy moved down in great numbers on the left flank, but the fire of the mountain guns caused them to withdraw hastily to the ravines and inaccessible coverts. Meanwhile the long string of camels, mules, and escort passed safely by, eventually reaching camp at Jagdalak Fort without loss of any stores or ammunition. Our casualties on this occasion were five men severely wounded, one dangerously. The enemy proved themselves adepts at this kind of warfare, when they are able to keep under cover of rocks and stones.

At Jagdalak Kotal, in the morning, Major Thackeray had heliographed to the General that the enemy had commenced building a *sanga* (stone breastwork) on the east side of the road, above the narrow pass between the Kotal and Jagdalak Fort, and the General having signalled to drive tle enemy out of the *sangas*, if possible, Major Thackeray started from the Kotal at about 12 p.m., with the 3rd Company, Sappers, with Lieuts. Dove and Randolph, R.E., and a detatchment of 18 men of the 4th Gurkhas, under Lieut. Bolton, B.S.C., for the purpose of driving the enemy from their *sangas*, above the pass. Lieut. Campbell, R.E., remained in command at the Kotal, with the 2nd Company, Sappers, and the remainder of the Company of the 4th Gurkhas. The enemy appeared in considerable force in the *sangas* on the higher crests of the ridge, and kept up a brisk fire, but without causing any casualties, as the nature of the ground enabled the men to keep under cover, until arriving at a point below the *sanga* nearest to the Jagdalak road. Here the men were halted, under cover, for two or three minutes for breathing time. Then a rush was made up the steep ascent by the main body, under Major Thackeray, a detachment under Lieut. Dove advancing a little higher up the ridge. The detachment of the 4th Gurkhas, under Lieut. Bolton, advanced still higher up the ridge, and captured two *sangas* on the higher spaces. The party remained in the *sangas* until 5 p.m., by which time the rear guard of our convoy moving from Pezwan, had passed the Kotal. About 2 p.m., the enemy were observed to be advancing in considerable force with standards and banners from the hills east of the ridge. Their advance was made in regular order, some were dressed in white and some in *khaki*, and all appeared to be armed with guns, rifles, or jezails, and Afghan knives, and *tulwars*. Lieut. Campbell, who had been left in command at the Kotal, signalled that they were advancing in three detachments, and at about 4.30 p.m., they attacked the *sangas* captured in the morning. They approached under cover of the rocks and stores, and opened a heavy fire which was replied to by the Sappers and Gurkhas. The men were ordered to keep well under cover. One of the enemy's standards fell, and their advance was further checked by the fire of Broadfoot's guns, which by this time had reached the Kotal, escorting the convoy on its way to Jagdalak Fort. As the convoy had now passed the Kotal, and the enemy were in great force, the Sappers and Gurkhas were ordered to return to the Kotal. This was effected without any casualties on our side. The enemy kept up a heavy fire, and at one time seemed inclined to come to close quarters. The detachment of Gurkhas performed excellent service, in covering the return of the party to the Kotal. Before leaving the ridge, the Sappers destroyed six of the enemy's *sangas*. The party under Major Thackeray had scarcely reached the Kotal, when the enemy descended the hill, and commenced a heavy fire from the rocks at the east side of the Kotal. It was now dusk. The Sappers and Gurkhas lined the parapets, and replied vigorously to the enemy's fire. The European signallers also did good service on his occasion with their Henry-Martinis, and killed or wounded several of the enemy.

During the whole of the day, the conduct of the 3rd Company of Sappers under their officers, Lieutenants Dove and Randolph, R.E., was excellent, and they behaved with great steadiness and bravery. Serjeant Bradford and the Native Officers shewed great coolness and courage, both at the capture of the *sangas*, and during the return to the Kotal. As it grew darker, the enemy's fire slackened a little, but about 9 p.m. was again renewed. As their fire, although heavy, appeared to do no harm, our men being well protected by the parapet and traverses, orders were given only to aim at the flashes, and to expend as little ammunition as possible. The Ghilzais raised much shouting, and called upon the Mussulmen to come out of the fort and join them. Receiving no replies, except an occasional volley, they seem to have become disheartened, and withdrew at about 10 p.m., without causing any casualties.

At Jagdalak Fort, on December 20th, news was received by General Gough from Sir F. Roberts, from Kabul, dated 18th December. Sir F. Roberts wished General Gough to advance at once to Kabul, taking up on his way Colonel Hudson of the 28th N.I., who commanded the post at Latabaud, held by 700 men, and 2 guns. The troops told off to accompany General Gough in his advance, numbered altogether about 1400 men, details as follows:

9th Foot, 450 men.
Detachment, 72nd Highlanders.
2nd and 4th Gurkhas, 800 men.
5th Company, Sappers, 73 men.
Hazara Mountain Battery, 4 guns.
Detachment, 10th Bengal Lancers.

Pezwan was held by a detachment of the 24th P.N.I., 2 guns R.H.A., 6th Company of Sappers, 1 Troop 10th Bengal Lancers. For the garrison of Jagdalak Fort on General Gough's departure, the following troops were detailed:

7 Companies, 24th P.N.I.
180 men, 10th Bengal Lancers.
2 guns, Hazara Mountain Battery.

At Jagdalak Kotal, December 20th was a quiet day; the earthworks were strengthened, and a small abattis was placed on two sides of the post.

Lieut. Blunt, R.E., Superintendent of Instruction in Signalling and Telegraphy, to the Sappers, arrived at the Kotal, and took charge of the signalling operations.

On Sunday, Dec. 21st., General Charles Gough, with his force detailed above, marched from Jagdalak Fort at sunrise, and reached Kabul on Dec. 23rd, without having met with any opposition. The march is described in General Gough's despatch, dated Kabul, December 26th, 1880, published in the *London Gazette*. The enemy appeared to have almost entirely withdrawn from the hills east of Jagdalak Kotal, very few being visible. The weather at this time was dry, and very cold at night. The health of the men was good. Advantage was taken of a quiet day to serve out some articles of warm clothing that had arrived with the convoy on the 19th, to the two companies of Sappers at the Kotal.

December 22nd passed quietly, both at the Kotal and at Jagdalak Fort. At the former post, a portion of the unfinished hut was roofed in with grass mats and earth, to render it fit for a hospital if required. The post now was as strong as it could well be made, and capable of resisting the attack of any force that an enemy unprovided with artillery would be likely to bring against it. Flat spaces were constructed on the south side of the post, outside the entrenchment for the transport animals. These were protected by an earthen traverse on the east side. Immediately in front of the flat space was a steep hill, at the bottom of which was the water course, from which the garrison procured their water.

On the 23rd December, the small force garrisoning Jagdalak Kotal, was composed as follows:

Corps.	British.				Native.			Grand Total.
	Field Officers.	Officers.	N.C. Officers	Total.	Officers.	N.C. Officers and Sepoys.	Total.	
Signalling detachment ...	...	...	5	5	...	...	...	5
Staff	1	1	1	3	1	1	2	5
2nd Company, Sappers ...	...	2	4	6	2	99	101	107
3rd Company, Sappers ...	...	2	4	6	2	96	98	104
24th P.N.I.	...	...	...	...	1	72	73	73
Totals ...	1	5	14	20	6	268	274	294

The English Officers present were:

Major Thackeray, V.C., R.E., Commanding the Garrison.
Lieut. Blunt, R.E.; In charge of Signalling.
" Dove, R.E.; Commanding 3rd Company, Sappers.
" Randolph, R.E.; Attached to do.
" Campbell, R.E.; Commanding 2nd Company, Sappers.
" Gordon, R.E.; Attached to do.

At about 2 p.m., the enemy appeared advancing along the crest of the ridge to the north east of the fort, and as they were in force, the signalling party which had proceeded in the morning to Signallers' Hill, returned to the Kotal.

The European signallers were told off to pick off men trying to cross the road between the Kotal and Jagdalak Fort, and the Sappers and the 24th P.N.I., under Subadar Jowakir Khan lined the parapets; the front ranks in the banquettes, and rear ranks remaining at the foot of the banquettes. The enemy, whose numbers could not be ascertained, succeeded in approaching to a distance of about 150 yards, and kept up a heavy fire, which was replied to vigorously, by the Sappers and Panjab Infantry. The enemy's fire was chiefly directed on the east face of the fort, and particularly on the entrance gate, which was blocked with earth and planks. Sepoy Sultan Ali of the 2nd Company, was killed while receiving orders from Major Thackeray. The men were kept well under cover. At about 2.30 p.m., the enemy were firing at ranges from 150 to 800 yards, and erected some *sangas* on the principal spurs. The east face of the fort was manned by the 2nd Company, Sappers, under Lieut. Campbell, R.E., and by the 24th P.N.I., under Subadar Jowakir Khan. The enemy kept well under cover, behind brushwood and rocks, and received reinforcements along the ridge.

They also opened a fire which threatened to be troublesome, from a hill about 200 yards in front of the fort, and from the higher spurs beyond, which rendered it impossible for the garrison to reply to the former without being exposed to a plunging fire from the upper spurs. A number of sandbags which had arrived the previous day, were brought into use, and a row of sandbag loopholes was constructed along the north parapet under the superintendence of Serjeant Hay, and Subadar Jewan Singh of the Sappers. At about 4 p.m., while directing the fire from the east face, Major Thackeray was struck by an Enfield bullet in the right arm. At about this time, fire was opened by the enemy from the ridge that commanded the west face of the fort, at a distance of about 300 yards. This necessitated the manning of the rear or south face which was exposed to the enemy's fire, from the high ground in front of the fort. The 3rd Company of Sappers, under Lieut. Randolph, R.E., were then posted in the flank bastions, and along a portion of the south face which was screened from reverse fire by some grain bags and engineering stores, that had been placed in the Quarter Guard tent behind it. A sandbag traverse was also commenced across the gorge of the bastion, at the south-west corner, by Sergeants Bradford and Lowden of the Sappers, to screen the men from reverse fire. The completion of the traverse, however, had to be deferred until after dusk, as the men were obliged to expose themselves when filling the sandbags.

At 6 p.m., the sky being clear, and the moon having risen, objects were still to a certain extent visible, and fire was opened by the enemy behind the spur, situated 100 yards from the south east bastion. The hill at this point is very steep, and the enemy was completely protected from our fire.

Twice or thrice, after much drumming and shouting, the enemy shewed in force on the crest of the spur with the intention of assaulting, but volleys from the fort drove them back under cover, from which they kept up a moderate fire. At this time, the enemy were firing from all round the fort except the left front, but the men being kept well in hand by Lieut. Dove, R.E., near the expected points of assault, and the light being dim, the men escaped without casualties.

The attack on the rear of the fort having failed, the enemy ceased firing at about 10 p.m., and were heard returning from the direction from which they had come. A few shots were fired by them at sunrise next morning, but no force was observed.

This was the final attack of the enemy on Jagdalak Kotal. The fort was afterwards held by 2 or 3 Companies of the 51st Light Infantry, and by 2 mountain guns.

The 2nd and 3rd Companies, Sappers, remained at the Kotal until the following month, and then moved forward to Lataband, where they were employed in improving the road and in other works. The 6th Company, Sappers, was also moved forward from Pezwan to Jagdalak Fort, there taking the place of the 5th Company, which went with General Gough's force to Kabul.

E.T.T.

January, 1880.

Appendix A.

List of Articles of Warm Clothing, authorized for British and Native Troops in Afghanistan, in 1879-80.

British Troops.

Waterproof sheets, English	1
Jerseys	1
Warm socks, pairs	1
Poshteen, or wadded coat, or other suitable warm garment	1
Boots, pairs	1
Caps, Balaclava	1

Native Troops.

Warm socks, pairs	2
Waterproof sheet	1
Mittens, pairs	1
Blankets	1
Poshteens	1
Shoes, native, pairs	1
Caps, Balaclava	1

Followers.

Blankets, country	1
Putties, pairs	1
Poshteens	1
Warm pyjamas, pairs	1
Shoes, pairs	1
Waterproof sheet	1

Appendix B.

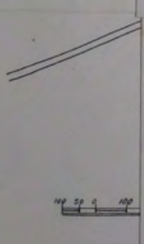
Return of Casualties during Attack on Fort at Jagdalak Kotal, 23rd December, 1879.

Jagdalak, 3rd January, 1880.

Corps.	Rank.	Name.	Casualty.		Remarks.
			Description.	Cause.	
R.E., B. S. and M.	Major	E. T. Thackeray, V.C. ...	Severely wounded.	Bullet in elbow.	
B. S. and M., 2nd Company,	Sepoy	Sultan Ali	Killed.	Bullet through brain.	
„ „	Kahar	Nanuk	Mortally wounded.	Bullet through back.	Since died.
„ 3rd Company,	Sepoy	Futteh Khan	Slightly wounded.	Bullet on skull.	
24th P. N. I.	Sepoy	Khuda Buksh	Dangerously wounded.	Bullet on skull.	Since died.

Four transport animals were also hit, two of which have died.

W. DOVE, Lieut., R.E.,
Late Commanding Jagdalak Kotal.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PAPER IX.

REPORT ON THE

FORTRESS OF GHAZNI,

By Captain and Brevet-Major E. M. Larminie, R.E.

No. 137 R.E., dated Shekabad, 28th April, 1880.

From—Captain E. M. Larminie, R.E., Commanding Royal Engineer, Ghazni Field Force,

To—The Deputy Adjutant and Quarter Master General, Kabul.

In accordance with instructions received on the arrival of the division at Ghazni, I have the honour to submit, for the information of Lieutenant-General Sir D. M. Stewart, a report upon the fortress of Ghazni and the present state of its defence, with plan and sketches to accompany it.

No. 851 K., dated Kabul, 2nd May, 1880.

Remark by Lieutenant-General Sir D. M. Stewart, K.C.B., Commanding in Northern Afghanistan.

In submitting the accompanying report on the defences of Ghazni, I have nothing to add, but that the actual condition of the defences at the present time appears to be very correctly described in the report.

Report upon Ghazni.

Taking into consideration that full accounts already exist regarding the position and situation of Ghazni in a geographical and descriptive point of view, it appears unnecessary to make any further remark beyond stating that its height above sea-level appears to have been over-estimated by several hundreds of feet, and that the perimeter or total circuit of wall given in former reports as 1,750 yards, inclusive of the citadel wall, is, after careful measurement, found to be 2,175 yards without the wall of citadel being included.

2. With a few slight exceptions to be noted hereafter, nothing whatever either in the shape of repair or new building appears to have been done since the date of our last occupancy, nearly forty years ago: hence the whole has fallen into a state of ruin and decay.

A ruined citadel, broken and useless parapets, cracked and tumbledown towers, crumbling curtain walls and a silted-up ditch, are all that remain of the once famous stronghold of Ghazni.

3. At the present moment a breach exists, extending from the terreplein of the citadel to the main ditch on the western front, and in two places in the southern face gaps, caused by the falling down of portions of the curtain wall, have been so feebly repaired and are so accessible, that a party of sappers could with crowbars and other tools form practicable breaches in the course of a few minutes, and that without any loss, as the flanking towers are here utterly broken down and useless. Even were these points non-existent, there are but comparatively few of the curtains capable of withstanding the explosion of a few bags of powder without falling down, and forming more or less practicable breaches. Indeed, such is the wretchedly feeble condition of some of these walls, that a battery of field artillery would probably be able to breach them with but a very small expenditure of ammunition.

4. The original brick and stone facing has, speaking generally, stripped and fallen off the walls and towers, leaving the earthen backing exposed to the weather, resulting in a considerable diminution of the original thickness; and the consequent weakness has been further increased by portions of the walls and ramparts having been hollowed out behind, to serve as dwelling places for some of the city people.

5. The *Mur-de-rondes* or *Fausse braie*, as it was termed in former reports, has, with the exception of that on one front, almost entirely disappeared, and has, apparently, with the upper portion of the escarp slipped or been washed down into the ditch, which has consequently become shallow and of little value as an obstacle.

6. No further demolition would render Ghazni less important than it is as a fortress; and taking into consideration its very defective construction, and the fact that from its situation a com-

mand of fire and observation will always be obtainable over the whole of it, no amount of repair could give it any real importance or cause any loss of time in reducing it.

Northern Face, A—B (Plate I). Has suffered less from decay than any of the others. The *Mur-de-rondes* is in a good state of preservation, and the ditch has not silted up; the parapet also is still in fair order, but inside the rampart has fallen away from it in many places, leaving it without banquette, and in others houses have been built up so as to render it useless. The Kabul gateway appears to have been cleared, and to a certain extent repaired since it was blown in by us, and the screen wall is also in fair order. The walls of this face was decayed, but not entirely stripped of the outer facing, and some of the towers are fairly perfect; but owing to the ruinous state of the rampart on the inside, this front has no real strength so far as the wall is concerned.

Eastern Face, B—C (Plate I). Here the *Mur-de-rondes* has disappeared, and the slopes of the ditch become more easy. The Kandahar, or Bazaar, gateway in this face consists of a domed building with gates opening straight through, and not as at the Kabul gateway, where the inner gate is at right angles to the first or outer. There is a broken-down tower and screen wall in front of the Kandahar gateway, but not of a sufficient height to serve its purpose. The ditch in front of this gateway has been filled up for a length of about fifteen yards. The walls of this front are much damaged, and a partial gap has been repaired by a wall which, though carried up to nearly the original height, is thin and constructed of broken bricks, small stones and rubbish, without any binding material.

The large tower or bastion between this face and the southern is perhaps the best preserved portion of the whole fortress, and was apparently added after the original design of Ghazni had been completed. The brickwork is still in great part perfect; but as the upper portion is merely a thin wall with rooms inside, the strength of this tower is more apparent than real.

Southern face, C—D (Plate I). Is in a miserable condition as regards defensive power; two of its curtains have had large gaps filled up to a height of 15 or 20 feet with mere apologies for walls. The *Mur-de-rondes* has entirely disappeared, and the ditch, which is here at a considerable distance from the wall, has become a mere shallow puddle; and as the foundations of the walls are here but little above the level of the edge of the ditch, it is a perfectly easy slope from the ditch to the wall. The towers on this side are much split and fallen down, and the *kanah*, or water gateway, has lost one of its towers, has no screen wall, and, like the Kandahar gateway, opens straight into the town, whilst in front, and for many yards on either side, the ditch has been filled up.

The outwork which formerly existed on the right bank of the Ghazni river, protecting the approach to the bridge in front of this gateway, has nearly disappeared; only a mound, about six feet high and $40' \times 26'$, with a couple of wing walls now remains.

Western face, D—A (Plate I*).* Derives any strength it may possess from the steep slope upon which the wall is built, as there is no rampart whatever, and the wall is pierced by many openings serving as windows to the houses built against the interior. In this face is the breach (marked *a* in plan) already spoken of as extending from the citadel downwards.

Citadel.—A house with courtyard, occupying in all an area of $90' \times 150'$, has been built on the terreplein, otherwise nothing has been done since the towers, &c., were blown down in 1842. The new building has no loopholes nor other means of defence. One of the towers at the end having a balcony and glass windows.

Well.—The well shown in the plan is lined with brick, is 4 feet 6 inches in diameter, has a depth of 73 feet, and at present has 2 feet of water in it.

Magazine.—A rectangular enclosure, with walls about 20 feet in height and 2 or 3 feet thick, with a building inside consisting of a series of domes of but little strength; the amount of ammunition, &c., found was but small.

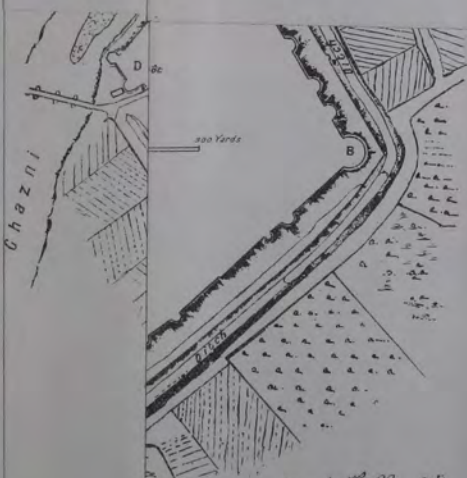
Guns.—The guns found were ten in number, all brass or bronze; four about 3 inches average diameter of bore and six 3-pounders.

City.—Is merely an assemblage of wretched houses, with nothing deserving the name of a street.

E. M. LARMINIE, *Captain, R.E.*

Commanding R. E., Ghazni Field Force.

20th April, 1880.



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27th April 1880.

PAPER X.

THE

BATTLES OF HALIJAS AND ZEWIN,

IN ARMENIA, IN 1877.

[*From the "Bulletin de la Réunion des Officiers," being a translation from a paper by Baron Rudolf von Schluga* in the Austrian Review of Streffleur.*]

TRANSLATED BY MAJOR C. WOODWARD, R.E.

WHEN in the Spring of 1877, Russia decided on declaring war against Turkey, the latter was in a critical position, and by no means in a position to successfully defend the extensive frontiers of her territory. In the Asiatic portion of the Empire every kind of preparation had been neglected up to the moment of the actual declaration of war, except in the case of Kars, which had been armed and provisioned, and in that of Batûm, which had been in some sort prepared. But everything else, the mobilization, armament, clothing, and provisioning of the troops, the concentration of the artillery and *matériel*, the supply of transport, and the organization of the cavalry and irregular troops was left entirely to the discretion of the Mushir, Achmet Mukhtar Pasha, who was appointed Commandant-General of Armenia in March.

Mukhtar had been educated at the Military School of Broussa, till 1855, when he was transferred to that of Constantinople, where he remained four years as a cadet, and one year as Under Officer. He showed signs of great military capacity, fully borne out by his subsequent career, and in 1866 he was appointed Captain on the

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* Baron Von Schluga, a retired Austrian Officer, was an eye witness of the events he describes, and which are still but imperfectly understood. The present paper is an abstract of the original.

Staff in Montenegro, where the veteran Omar Pasha had successfully commenced the campaign. This campaign taught Mukhtar mountain warfare in the most complete manner; and the knowledge, skill, and indefatigable energy he afterwards displayed, were acquired and developed on this occasion. On the conclusion of this campaign, Mukhtar was appointed Professor of Astronomy and Fortification in the Military School, when he commenced a work on the former science. Afterwards he served with distinction in Northern Syria, and in 1867 accompanied the Sultan in his European trip. On his return he was employed in regulating the Montenegrin frontiers, and afterwards had virtual command, through the illness of the Commander-in-Chief, Redif Pasha, of the expedition to Yemen in South Arabia; where, after the country had been pacified, he remained three years as Governor. He then was appointed to Crete, but had hardly landed when he was recalled, it having become evident that Russia was bent on war, and placed in command of the 2nd Army Corps at Schumla, when in thirteen months he completely fortified the position. At the imminent approach of hostilities he was appointed to the command of the 4th Army Corps in Armenia. He was then 40 years of age, a true soldier, just to his subordinates, simple in his habits of living, capable of undergoing great fatigues and privations, and an ardent and sincere patriot.

Before the actual outbreak of hostilities, Mukhtar encountered every possible obstacle in organising the Army of Armenia. The Government at Constantinople, with serene indifference, opposed any attempt at even merely precautionary measures. Mukhtar's Chief of the Staff was Mehemed Feizi Pasha (the Austrian retired Colonel Kollman), a very capable officer, and who had served in the heroic defence of Kars in 1855, but whose age—71 years—soon compelled him to confine his duties to that of an adviser only.

There was a complete dearth of the secondary grades of generals in Armenia, and the few present there were either old and infirm, or energetic without knowledge; none were capable of either replacing or assisting the Commander-in-Chief. Nor could any capable officer be spared him from Europe, with the exception of Chefket, Hadji-Rashid, and Mustafa-Savfet Pashas.

It was not till the beginning of June that any troops from the reserve came in to fill up the cadres of the regular forces, which Mukhtar had concentrated at Kars and Bayazid. He had organized an irregular Circassian Cavalry under the orders of two generals of brigade, Musa Pasha and Gazi Mehemed Pasha, a son of Schamyl, and had made some arrangements for transports, by which each battalion procured for itself the number of bât animals it required. For the provision columns, bât animals, two wheeled country carts, and especially camels, were obtained.

The preparations for the defence of Erzerûm, proceeded very slowly for want of troops, and on account of the bad state of the roads. Heavy guns of position remained for weeks hopelessly fixed in the mud.

On April 18, Mukhtar Pasha arrived in Kars. The garrison was composed of 29 battalions of Nizam (the Line), of 500 men each; 3 squadrons of regular cavalry, and 300 Kars Mounted Volunteers, and 5 batteries of field artillery of 6 guns each; in all about 20,000 men, in 2 divisions. Hussein Hami Pasha was placed in command.

In the night of the 23rd-24th April, the declaration of war not having yet reached Constantinople, and therefore before Mukhtar Pasha was aware of the commencement of hostilities, the Russians crossed the Arpa Tchai, (see *Plate* I.) and surprised the outposts. The next day the central invading column, comprising the grenadiers of the Caucasus, the 19th, 38th, and 40th Divisions of infantry, occupied the plain of Kars. The 41st Division watched Batûm; the 20th, Sukkûm Kalé; the 39th, Bayazid. The 21st Division was in reserve in the Caucasus.

In the night of the 25th-29th, Mukhtar, fearing to be shut up in Kars, left it with 5,000 men and one mountain battery. He was pursued without result to the Soghanli Dagh, and took up a position at Hunkiar Düzü. Here he remained till May 20th, without having been able to procure reinforcements, but unmolested, the Russians probably having no idea of the weakness of his force.

On the 21st May, Mukhtar learned the capture of Ardahan. As it seemed therefore probable that the Russians would march on Erzerûm by the Ardahan-Olti road, he retired to Tchakir Baba; whence, by a forced march by Bardes, he might fall by surprise on their right wing near Olti, before they could have perceived his movement.

But now the head of a column of 10 battalions of Syrian redif (reserve) had arrived at Erzerûm, of which 3 battalions and a field battery, were pushed to Olti, together with an Armenian battalion. One Armenian and seven Syrian battalions, one or two field batteries, and one of mountain guns, reinforced the centre. The Russians however made no sign of penetrating to Olti.

On the 29th May, a reconnaissance made by Musa Pasha towards Kars, with 500 Circassians, and 2 mountain guns, was surprised at Begli Ahmed, and the guns were lost.

Mukhtar thus learned that the main body of the Russians were still at Kars; he therefore concentrated at Zewin, and at the end of May he had disposed his forces as follows:

At Zewin, forming the centre

1st Division.	Ahmed Muhlis Pasha, in 4 brigades under Chefket, Ahmed Fazyl, Shakim Pashas, and Col. Hakki Bey	21 battalions.
	Cavalry, 2 brigades, Mustafa Savfet, and Musa Pashas	12 squadrons.
	Artillery, 2 field, and 1 mountain battery	16 guns.

or a total of 10,500 infantry, 900 cavalry, 16 guns.

At Olti, 1 battalion; at Pennek, 2 squadrons of irregulars, forming the left.

At Alajgerd, forming the right:

3rd Division.	Mehemed Pasha, in 2 Brigades, Mustapha Jawad Pasha and Akif Bey ...	12 battalions.
	Cavalry, 300 irregulars	3 squadrons.
	Artillery, 1 field, and 1 mountain battery	12 guns.

or a total of 6,000 Infantry, 300 Cavalry, 12 guns.

Mukhtar's whole force therefore consisted of 17,000 infantry, 1,400 cavalry, 28 guns.

The outposts observed the defile of the Kanli Dagh in front of Pennek on the left, the Soghanli Dagh in the centre, and the Bayazid road at Toprak Kalé on the right.

Some reserves were also in course of formation in the rear; 4 battalions at Keupri Keui, 3 at Hassan Kalé, and 4 at Erzerûm. 11 battalions, or 5,500 men and 15 guns.

The position taken up by Mukhtar Pasha possessed great strategic advantages. 1st. It commanded the main road between Kars and Erzerûm. 2nd. Its left could only be turned by an enemy making a long detour through the Olti Valley, a movement easily met by a small movement of the centre towards Olti or Nerimen, without the necessity of evacuating the main position. 3rd. The right could not be attempted by an enemy even superior in force, as it would be compelled to engage itself in the deep Khorassan Valley, where it would be met in front by the main body from Zewin, and in flank and rear by the wing at Alajgerd.

The tactical advantages were also great, and it could be held with a a small number of troops. Its naturally very strong features were supplemented by works thrown up in the course of the month. It could only be forced by a very superior army. (See *Plates* II. *and* III.)

The position of Zewin is on the west bank of the Tchan Suju, an affluent of the Araxes, rising in the Soghanli Dagh, and flowing from north to south. This river is, in summer, fordable nearly everywhere. The heights bounding its valley are steep, and in places rocky; the right (west) bank being the steepest. The main Kars-Erzerûm road, crosses the stream at Zewin, coming down the valley from the north on the left bank. After crossing the stream, it branches, one road following the right bank to Khorassan, the other ascending the heights to the west. Another road leads out of the Khorassan road, 4,000 paces south of Zewin, and also climbs the heights to the west.

The heights behind Zewin formed the Turkish position. They are a granite upheaval, along which rise four summits from 100 to 140 metres above the river bed. This range was occupied by the advanced posts, protected by shelter trenches. It falls rapidly to the rear towards the west, where a second somewhat higher range of heights rises in a semicircle, 5,000 paces long, and with the first range encloses a sort of basin. On this second range of heights was the first line of the main body, occupying a complete system of defensive field works.

The top of this second range formed a plateau, 12 to 15 hundred paces wide, still however rising to the west. On the western edge, the second Turkish line was entrenched. Beyond this the heights fell by narrow scarped ravines into the elevated plain of Horum-Düzü, where the reserves and the camps of the cavalry, trains, and Administrative Staff were placed.

The works for the defence of this position had been in hand for a month, and after they had been completed to an ordinary degree of strength, the troops occupying the various sections of the position employed themselves voluntarily in strengthening the parapets, deepening the ditches, and in very intelligently adding to the defensive strength of the works comprised within their sections.

At the time of the Russian attack, the position of Zewin offered the following dispositions.

1. The line of advanced posts was weakly entrenched on the easternmost and lowest range, the labour employed on it was mostly in forming shelters and huts with branches.

2. First line. The right wing covered the southern road to Erzerûm, and was composed of 2 battalions, in a work C crowning a knoll, 1 company in an outwork D closing the road, 1 battalion

occupied a trench B of strong profile on the extreme right. Abattis and shelter trenches covered the fronts of all their works. The total length of the right wing was 1,500 paces, held by 1,500 men. In case of need the 2nd line would act as a support.

The centre, 6 battalions and 6 guns, occupied the range between the two roads. Its right was protected by a closed work D, its left by another, G, guarding the two roads. The front between these two works was protected by a trench of a strong profile, covered in front by stone parapets for sharp-shooters, placed 10 to 15 paces below the crest of the ridge, and so managed that every small valley and hollow of the ground in front was seen into from them. Such of these works as were necessarily exposed to enfilade fire, were provided with stone traverses. Two emplacements for one gun each, were arranged along the line, and the redoubt G on a hill called Top Dagh held 4 guns. The total length of front of the centre was 3,600 paces, held by 3,600 men, and 6 guns.

The left wing J stretched to the road going straight to the westward from Zewin, and was protected by a system of shelter-trenches in terraces, one behind and above the other. A lunette L, called Horum-Düzü Tabia, formed the extreme left of the front, and was armed with 2 guns.

The extent of the left wing was 1,500 paces, defended by 1,200 men, and 4 guns.

3. Second line EE^1 was 3,600 paces long, with a covering trench intended rather as a protection against projectiles passing beyond the first line than for active defence. Four battalions (2,000 men) with 6 guns occupied this line; 2 battalions being entrenched in two redoubts A, K, in rear of each flank.

For the execution of the works, the staff had organized several special detachments of workmen chosen from among the most robust and experienced of the troops, and those among them who were natives of Anatolia were peculiarly adapted for the task. For the materials of the 1st line, the pebbles and small boulders, which cropped up everywhere from the surface of the turf, were utilised, but all the available earth to be found was also employed. To these materials some small woods furnished a valuable complement of timber, some 20 to 25 years old. The trees were all turned to account, and fascines and gabions were made from the brushwood.

Each battalion contained 200 men provided with heavy but serviceable picks, and large and solid shovels. There were no wheelbarrows, but the excavated earth was carried in baskets. There was some excavation in rock, which was effected by gunpowder. The shelter-trenches of the 1st line had openings through them for the passage of sorties. The ditch was about 5 ft. deep, and 2 ft. 6 in. wide at the bottom. On the reverse slopes of the heights, where the ground was not too steep, ditches were made 5 ft. deep, and, at 2 ft. 6 in. in advance of the crest of the counterscarp, strong pickets were driven nearly close together, 2 ft. 6 in. into the ground. Iron wire was then interwoven between them, forming a sort of crate, which being filled up behind with stones and earth, afforded a parapet 3 ft. 3 in. thick. Where the slope of the ground was too great for this, a narrow platform 5 ft. wide was formed along the contour, on the outer edge of which was erected a parapet of large stones 5 ft. high, and 2 ft. 6 in. thick. Where these trenches were enfiladed traverses, 10 ft. high, of stone and earth, were spaced at distances of 10 paces. These trenches afforded a high degree of security to the troops, and inspired them with great confidence, though they could only be reinforced with loss, and the form of the defences rendered sorties difficult. On the right wing a small wood was surrounded by shelter trenches and a good solid abattis. There was nothing of importance in the construction of the artillery emplacements. It was not practicable to form ditches round them; platforms were built up with stones, and the parapets and traverses stood on these.

In this position Mukhtar Pasha exercised and organised his troops into divisions and brigades of 12 and 6 battalions of 500 men, in 8 companies respectively. The battalion was the administrative unit, and was charged with the duties of procuring food and transport for its strength. The train of a battalion was composed of 80 mules or horses: 10 carried the tents (4 tents to each animal), 20 the reserve ammunition (2,000 cartridges per animal = 80 per man), 10 the tools and cooking utensils, 10 the Officers' baggage, 30 biscuit and other provisions. The normal load of each beast was fixed at 125 kilos. (268 lbs.). Thus provisions for 5 days could be carried with the battalion, though it often occurred that battalions were engaged for a longer period on the march, or in action, without being able to replenish their supplies.

The troops were generally armed with the Snider and bayonet, but all the reinforcements which arrived after the battle of Zewin were armed with the Martini-Henry. The clothing was very defective, and the mantle worn by the troops was insufficiently warm for the severe temperature of the Armenian plateaux; for boots, the men had stockings of coarse cloth, under which stout leather soles were attached by means of cross lacing, which was carried up as far as the knee. This proved quite sufficient.

Besides his arms, each man carried a haversack containing his particular property. In the two cartridge pouches he carried 80 cartridges, and in addition as many more as he could in cartridge pockets made by the men themselves, in the Circassian manner, sewn on to the dress. In this way some men carried as many as 120 cartridges. It may be mentioned that there was no want of cartridges during the campaign.

The administration served out no intoxicating drink, coffee, nor tobacco, but a brisk trade in the two latter articles was carried on in the camp, for although the troops received no pay, they were supported pretty well by their families. Flocks of sheep, replenished from time to time from the main flocks following the army at a distance in rear, accompanied each battalion. There was no beef, flocks of sheep being of quieter locomotion than herds of cattle.

There was considerable activity in the instruction of the men. The mornings were devoted to works of fortification, the afternoons to tactical exercises. The chief manœuvres consisted in the successive formation, reinforcement and retreat of lines of skirmishers, then in bayonet attacks, and in re-assembling troops after being dispersed. A normal disposition for the attack was adopted and thoroughly practised. The company was divided into 4 sections, 2 in advance in open order, 1 also deployed at a distance in rear of 200 paces; the 4th in close order formed the reserve. In attacking an enemy's position, a violent fire was first to be opened upon it from a commanding position, if possible; this fire was to be constantly reinforced, and at last carried on for three or four minutes, as intensely as it could be maintained. If then the enemy were not sufficiently shaken to warrant an attack by the bayonet, one, or sometimes two sections were withdrawn to the position of the supports from whence they covered the retreat. But if the effect of the fire could be considered sufficiently great to justify a bayonet attack, 3 sections only advanced; the 4th formed in extended order remained to cover the retreat in case of repulse. The same principles were taught in the defence of a position; a portion only of the force was to be employed in repulsing the attack, except in cases of absolute necessity. In case it was impossible to repulse the attack, 2 sections were to be at disposal to attempt a counter attack, or cover the retreat.

At the commencement of the campaign, the cavalry was much dispersed. Of the 24 squadrons of the 4th Army Corps, 6 were at Batûm, 3 had been taken prisoners at the Arpa Tchai, 1 had been broken up after the capture of Ardahan, 2 were between Bayazid and Van, 6 were at Erzerûm, and on the line of communications; only 6, amounting to 300 horse, remained with the troops in position. Mukhtar had with him about 1,100 Kurds and Circassian Volunteers. These were formed into squadrons of 100 each.

The artillery consisted chiefly of 8*cm.* Krupp guns, breech-loaders. The advanced trains contained 30 rounds per gun; the reserve carried 60 rounds additional. The wagons were good, the horses were strong Syrian animals, 8 to each limber and each wagon, and perfectly well harnessed. The mountain batteries (Whitworth's system) had 24 bât animals; 6 for the guns, 6 for the carriages, and 12 for the ammunition. All the appointments were new, and the officers and men were very well instructed in their duties.

The sanitary services were only gradually organised as the campaign proceeded. A provisional hospital was established at Zewin, in charge of two surgeons, but it was wanting in nearly all necessaries. A few battalions were provided with surgeons, who were obliged to go themselves to Erzerûm, when it was necessary to renew their supplies. No private ambulances, nor those of the Red Cross, were despatched to the Armenian theatre of war.

The principal magazines for provisions and stores were at Erzerûm and Baiburt.

Telegraphic communication in all directions was in active operation through the central stations of Erzerum and Keupri Keui. Telegraphic communication with Kars was not interrupted till June, while that by means of messengers was always kept up.

At the beginning of June, Col. Komaroff passed the defile of Kanli Dagh, with a portion of the column hitherto employed before Ardahan. The Turkish outposts fell back on Bardes. The Russian advanced guard consisting of 1 battalion, 1 cavalry regiment, and a battery, occupied Olti, and on the 2nd June, reached Nerimen on the direct road to Erzerûm. Mukhtar Pasha resolved to surprise it, and for this purpose, a force of 3 battalions, 1 battery, and all disposable cavalry, was to move as quickly as the circumstances required, but the Russians learning the combination against them, retreated beyond the Kanli Dagh.

On the 14th and 15th, the Russian centre made a violent attack on Kars, which was repulsed with loss.

General Tergukasoff, commanding the Russian left, 9,000 infantry, 3,000 cavalry, and 32 guns, advanced slowly towards the Deli Baba defile. Mehemed Pasha, whose force consisted of 6,000 infantry, 300 cavalry, and 12 guns, fell back before him. On the 16th June, being ordered to retake a position he had abandoned the day before, he attacked the Russians, but was repulsed with a loss of 129 men, he himself being among the killed. The Turks retired unpursued to the Deli Baba pass, through which they retreated, and took up a position behind it.

Combat of Halíjas.

This slight success of Tergukasoff made much sensation at Erzerûm, and Mukhtar Pasha was pressed to attack the Russians. He, however, looking on Tergukasoff's advance as a mere demonstration to divert his attention from the Erzerûm-Kars road, on which he was convinced the main attack would be made by the Russian centre, and knowing that Faik Pasha had commenced a movement from Van, chiefly with irregulars, on Tergukasoff's communications, preserved his coolness, and resolved to adhere prudently to his own plans.

His forces at this date were disposed as follows:

	Battalions.	Squadrons.	Guns.
Left wing at Olti	4	2	6
Centre at Zewin	21	12	18
Right wing at Deli Baba	12	3	12
Reserves at Keupri Keui	4		
" Hassan Kalé	3		
" Erzerûm ...	1	12	27

There were also at Erzerûm 13 battalions of troops of the reserve (mustafiz), and 1,000 Circassian cavalry in course of formation.

On the 18th June, Mukhtar ordered Fazyl Pasha, commanding the 2nd Division at Zewin, to proceed to Deli Baba, and take command of the 3rd Division. The cavalry in the Soghanli Dagh, was to push as far forward on the Kars road as possible, to reconnoitre the movements of the Russian centre. Ten squadrons were to move up under Ghazi Mehemed Pasha to Keupri Keui.

On the 19th, Fazyl Pasha reported from Deli Baba that the Russians had not occupied the passes, but that the position of the 3rd Division at the western outlets was bad. The cavalry thrown forward towards Kars reported no movement to be visible in the enemy's lines. On these reports Mukhtar Pasha resolved to attack General Tergukasoff before he could obtain reinforcements, and seize the passes of Deli Baba. He accordingly ordered the follow- dispositions.

Ghazi Mehemed Pasha was to continue his march with his 10 squadrons in the night of the 19th-20th June, to Deli Baba, and, having rested there, to move through the Deli Baba and Derbend passes, and occupy Eski Kilias and Haidar Keui. The 4 battalions at Keupri Keui were to occupy Deli Baba, their places at Keupri Keui being taken by the 3 battalions from Hassan Kalé. The 2nd Division at Zewin under the temporary command of Shakim Pasha, and consisting of 9 battalions, and 1 field battery, was to move to its right to Deli Baba, whither also the 2nd cavalry brigade (Musa Pasha, 6 squadrons) in advance at Mendjiugerd, behind the Soghanli Dagh, and the 1st cavalry brigade (Mustapha Safvet Pasha, 6 squadrons) in advance at Jeni Keui, were to march, the latter leaving 4 squadrons at Zewin. The garrison of Olti was to move to Zewin with 4 battalions, and 1 field battery. Ismail Hakki Pasha (called by the people Kurd Pasha) Governor of Erzerûm, was left in command at Zewin, with orders to hold that position to the last man. On the 20th June these orders were put into execution. The troops marched without tents or baggage, taking only ammunition, tools, and food for five days. The next night the 25 battalions (12,500 men), 21 squadrons (2,000 men), and 18 guns were concentrated about Deli Baba. Some of the troops had to march nearly 25 miles to come into position, besides having to ford the Araxes at Daj Khodja, 250 ft. wide, the water being up to the men's necks.

The Russians had now advanced to Tahir Keui. (See *Plate* IV.)

The road from Bayazid to Erzerûm runs along the north or left bank of the Murad Su—the Eastern Euphrates. At Sedikian, the road through the Deli Baba Pass turns off; at Tahir Keui, 6 miles further, a road branches off to Eski Kilias, and thence over the Halijas plateau, through the Kara Derbend Pass. Beyond Tahir Keui the road goes through Kalascu and Abaza to the Hadji Khilal Pass. These passes are about 3 miles apart, and lead over the ranges separating the valley of the Murad Su from that of the Araxes. At the eastern or Bayazid *debouché* of the passes, is an elevated plain, the Halijas, or desert, which lies between two streams forming the sources of the Murad Su. At the eastern limit of this plain are two elevations, one behind the other, commanding the southern stream by nearly 1,000 feet.

Mukhtar Pasha now made the following dispositions. The 1st and 2nd brigades of cavalry, and the 2nd division, reinforced by the 4 battalions from Keupri Keui, were to march by the Kara Derbend pass to Eski Kilias, followed by 4 battalions of the 3rd division with a mountain and a field battery, under Jawud Pasha. These latter troops were to turn towards Haidar Keui after passing the defile, and to entrench themselves there. The other 8 battalions of the 3rd division were to remain provisionally in reserve between Kara Derbend and Deli Baba. The 2nd division and the cavalry were to attack the enemy in front, supported and protected in case of repulse by Jawud Pasha's detachment; the 3rd division was to operate on the enemy's flank and rear if the attack were successful, but was also to be in readiness to be thrown back to the Araxes should the Russian centre attack Zewin in superior force.

The 2nd division marched at 7 a.m., and reached Eski Kilias at 10 a.m. From here it advanced in two columns, directed upon the heights, marked 300 and 240 in *Plate* IV. Ghazi Mehemed's Circassian cavalry covered the front, and the two brigades of cavalry advanced into the Valley of the Murad Su to cover the right flank.

With incredible difficulty, 3 field pieces were hoisted up to the summit of the Top Dagh (marked 300), and were established behind epaulments of loose stones. Four mountain guns (the other two having been disabled) were also established on the height 240, on the left. The skirmishing line was pushed down the eastern slope towards Tahir Keui. About half-way down, where the slope flattens out into a sort of plateau, the Turkish advance was arrested by a sharp fire from the border of the village, and the skirmishers hastily covered themselves with a line of shelters formed of stones. Meanwhile, the Turkish guns opened fire on a Russian battery of 12 pieces, at a range of 2,600 yards. The cavalry on the right flank found itself in presence of imposing masses of cavalry, which crossed the Murad Su at Karasul, and commenced to form in the plain.

Mukhtar Pasha having thoroughly comprehended the Russian position, telegraphed back to Deli Baba, for the field telegraph had kept up with the advance, and ordered up 6 battalions; 4 to join the Turkish left, 2 to occupy Haidar Keui; of the 4 battalions now posted at this village, 3 were to move up on the Turkish right; 1 battalion was still to remain at Deli Baba, and 1 was to fall back to Khorassan to keep up communication with Zewin. The 3 battalions from Haidar Keui might be expected to be in line at 2 o'clock; the 4 from Deli Baba at 4 p.m.

The Turkish left and centre remained thus, in close contact with the Russian entrenched position from noon. On the right, the cavalry attacked the Cossack cavalry and dragoons of the enemy, but suffered severely, chiefly owing to the fire of the dragoons, who had dismounted, and occupied the village of Karasul. The Turkish cavalry fell back to the point marked 300. All this time the cavalry which had preceded the Turkish advance had remained in the valley between the Russian position and the hills forming their own line of battle, when, exposed to a close fire they suffered severely, but now, 200 strong, they formed up and charged round the Turkish right flank along the Murad Su, and broke through the enemy's squadrons. A fierce fight took place, and both sides lost considerably. The Turks, however, gained their point, and the Russian cavalry from henceforth remained strictly on the defensive.

At 2 p.m., the 3 battalions from Haidar Keni arrived, and were placed in the prolongation of the line of battle to the left. Mukhtar still awaited the troops from Deli Baba before attacking. However reports reached him that the progress of this force was arrested in the pass by the stream of wounded and stragglers, and he despatched a battalion from Eski Kilias to the pass to keep order. The day was closing in, and these troops had not yet come up, so that at 4.30 p.m., Mukhtar Pasha determined to attack without them.

Of the 9 battalions composing his left, he sent $7\frac{1}{2}$, in six columns, against the Russian right, and the whole north-west front of the position was carried at the first rush. The battalion on the extreme left of the attack (Redifs of Siwas) advanced against the battery in rear, and compelled its retreat. The Russians abandoned their works, and fled towards the interior line followed closely by the Turks, who entered this line with them. But the Russians sent up 3 strong battalions from the reserve behind Tahir Keni, and drove back the exhausted and disorganized assailants, re-occupying the entrenchments. Again the Turks captured this front, and again they were driven out, for while the defenders were being constantly reinforced from their reserves, the assailants had no reserves at all. The Turks fell back and rallied under the protection of their mountain guns; 3 battalions under Akif Bey having come up from Deli Baba, Mukhtar at 7 p.m., ordered a new assault to be made with 10 battalions, still on the Russian right front and flank. The works were again carried, but no impression could be made on the interior line which had in the meanwhile been greatly strengthened. Nor could the captured position be held under the concentrated fire of the batteries which the Russians again brought up into action. At nightfall, the Turks fell back into their own positions of the morning, exhausted, short of artillery, ammunition, and with a loss of 2,000 men, of whom half were dead or dying. The action had not been a success, and Mukhtar Pasha began to fear he had altogether underrated the enemy's strength, but he was confident in the good spirit of his own troops. The weather had been exceedingly hot during the day, and at night fell to 26° Fahrenheit. Forage, wood for firing, and water were not to be had, and the men had no tents, and but biscuit to eat.

Nevertheless Mukhtar, during the night, telegraphed for all his immediate reserves, on the arrival of which he intended again to attack in the morning with 26 battalions and 3 batteries. Ghazi Mehemed Pasha, with a brigade of cavalry, was ordered to cross the Murad Su, to reconnoitre the enemy's left flank. But during the night, the Russians retreated, abandoning their positions, which the Turks hastened to occupy. They fell back in good order, covering their retreat with a slight cannonade, and took up a new position a few miles in rear. Their losses had not been more than half those of their assailants.

On the 23rd, Mukhtar Pasha heard that Loris Melikoff had concentrated at Keketch on the 21st, with 20 battalions, 5,000 cavalry and 32 guns, and that he had advanced to Sari Kamich on the 22nd.

Combat of Zewin.

In fact, Loris Melikoff had heard on the 20th from his patrols, and from Tergukasoff, that a considerable movement of the enemy's troops was taking place, clearly pointing to an attack on the Russian left wing. There was no time to reinforce this wing directly, nor to oppose the Turkish movement, and he accordingly resolved to wait events with a strong column on this side the Soghanli Dagh, and thus indirectly relieve the pressure on his left.

For this purpose, the division of the grenadiers of the Caucasus, 4 battalions of the 30th division, 8 regiments of cavalry, and 32 guns, left Keketch the 21st, reached Sari Kamich the 22nd, crossed the Soghanli Dagh the 23rd, and advanced to Milliduz, pushing their outposts as far as Mendjingerd, to which position the whole force moved forward the next day, and halted, awaiting more certain intelligence concerning the operations at Alajgerd. In this position the Russians could either move on Khorassan, and act against the rear of the Turks at Deli Baba, or advance against Zewin, and so prevent Mukhtar from profiting by a victory at Halijas. Having definitely heard that the Turkish commander-in-chief was himself at Alajgerd with considerable reinforcements, he decided for the attack on Zewin on the 25th.

During the evening of the 24th June, and the following night, a strong body of Russian cavalry was pushed to Khorassan, where

Musa Pasha's cavalry, 5 squadrons, and the battalion detached from Akif Pasha's command had taken post. These troops fearing to be cut off, retreated to Keupri Keui, and so the communication between Zewin and Alajgerd were cut off.

The Turkish commander at Zewin, seeing the continual arrival of strong bodies of Russian cavalry at Khorassan, and the retreat of Musa Pasha, at first concluded that the enemy's plan was to penetrate between the centre and right and isolate them from each other. The advisability of retreating from Zewin to Keupri Keui, in order to cover Erzerûm was accordingly discussed, but at 10 a.m., such considerable forces of infantry and artillery were seen advancing directly on the Mendjingerd road that it was clear an attack on Zewin was intended. About noon, the Russian skirmishers began to cross the river Chan Suju, and ascend the heights towards the Turkish position.

The line of Turkish outposts on the lower range was not able to resist the Russian advance, which was made with great spirit, and it fell back on the main position. Encouraged by this success, Melikoff at once pushed forward his troops for the attack of this position, without having prepared the way by an efficient artillery attack. It is true that 19 guns had been brought up in a single line south-east of Zewin, and had cannonaded the Turkish line since 11.30, and another battery of 5 pieces had been placed farther to the south, but the results of the fire had been insignificant.

The formation of the columns of attack was made about 2 p.m. on the slopes of the captured line of the Turkish outposts. The left column, 4 battalions, was to attack the works at Arab Tepe, (C D *Plate* III.), that of the right, 6 battalions strong, was to attack the centre, and especially the works guarding the road.

As soon as the assaulting columns emerged from their shelter below the lower ridge, they were received with a murderous fire. The troops pressed down the reverse slope of the ridge, hoping to find cover in the numerous gullies at the bottom, but these were effectually seen into by the advanced stone shelter trenches of the main position. The men fell fast, and it was impossible to remain there. They therefore pushed on and began to ascend the slopes of the main ridge, losing heavily.

The extreme Russian left sought to turn the Turkish right, and being rather better covered than the other parts of the assailing front, succeeded in holding firmly their position in front of the enemy. The turning movement was prevented by the advance of a Turkish battalion from the second line, and no impression could be made upon the defenders. The Russians, however, persisted till 9 p.m., when they finally retreated.

The attack on Arab Tepe was made with great energy, and the Russian battalions got up close to the edge of the small entrenched wood in front. It was impossible to advance farther, although another battalion was brought up from the reserve. At 5 p.m., the 4 Russian battalions, terribly shattered, fell back, reformed behind the hill marked 125, and recrossed the river.

Nor was the attack on the centre more successful; it was found impossible to get up to the advanced works. At last, reinforced by 2 battalions from the reserve, the Russians succeeded in advancing, though with most serious loss, towards the Top Tepe (G). But the Turks brought up some supports from the second line, who fell upon the assailants with the bayonet, and drove them off. The retreat on this part of the attack degenerated into a rout, the troops only reforming at about 6·30 p.m., on the farther bank of the Chan Suju.

During the assault, the Russian artillery had directed its fire on the ground in rear of the main Turkish line, thinking the reserves were massed there. There being no reserves, this fire was wasted. Between 3 and 5 p.m., ammunition began to fail, and fresh supplies were only brought up at the latter hour.

Loris Melikoff seeing the uselessness of repeating the attack, decided on retreating. The troops detached towards Khorassan, 4 battalions, 8 guns, and a strong force of cavalry were recalled, and to cover the retreat he ordered his last reserves, 3 battalions, 5 squadrons, and 4 guns to advance into the valley of Zewin to attack the Turkish left. The movement was observed, and opposed by 2 battalions, 4 squadrons and a battery from the second line. In the end it was vigourously repulsed. The Turkish cavalry here missed a great opportunity of inflicting heavy loss on the disorganized enemy, but instead of charging the broken and retreating troops in front, they endeavoured to take them in flank by ascending the northern slopes of the Zewin stream, wheeling along the plateau and descending again on the flank and rear of the enemy. From the steepness of the slopes the movement failed, and the Turks lost from 80 to 100, by the fire of the retreating infantry. At 7 p.m., the combat was over. The Russians retreated and camped at about 5 miles from the Turkish outposts. Their losses as stated in the official accounts were 900 killed and wounded, but according to the statements of the officers themselves, they were nearly 3,000. The Turks lost 138 killed, and 502 wounded. Had the Turkish commander pressed the pursuit vigorously, the enemy could only have saved themselves by abandoning their artillery and supply trains, but acting too strictly on Mukhtar Pasha's orders, no pursuit of any kind was attempted.

The whole Russian army retreated towards the frontier. Mukhtar Pasha, leaving Achmed Pasha in command of the right wing at Alajgerd, resumed command at Zewin. On the 29th June, he followed up Loris Melikoff with 29 battalions. On the 9th July he raised the siege of Kars, and the next day made his entry into the fortress he had relieved.

C.W.

PAPER XI.

THE

FORTIFICATIONS OF VERONA,

[*From the Italian.*]

BY LIEUT. M. NATHAN, R.E.

Fortifications erected before 1830.

IN the year 1830, the fortifications of Verona were as follows:

1. The old works of the Sammicheli, viz.: On the right bank of the Adige, the bastioned enciente, which still forms, as it did then, the western and southern boundaries of the city, extending from the Bastion of Spain to that of S. Francesco, and, on the left bank, the enciente between the Porta Vittoria and the Porta Vescovo, which surrounds the south-east part of the city.

2. The embattled wall on the east and north-east of Verona, erected by the Scaligers, and comprised between the Bastion of S. Toscana, and the Porta S. Giorgio.

3. The Castle of S. Felice (to a great extent destroyed), which completed the above mentioned enciente. It has now been rebuilt, and fulfils the same object in the present system; it was commenced in the year 1393, and finished by the Scaligers.

4. Finally, the Old Castle, on the right bank of the Adige, with its fine bridge, the work of the Scaligers, between 1355 and 1358.

Fortifications erected between 1830 *and* 1838.

Thus, Verona was certainly a walled and fortified city, but, to say nothing of the damage done to its fortifications in 1801, there was at that period, in which instruments of destruction had already reached a tolerable degree of perfection, hardly a fortress able to sustain a regular siege. Hence the aim of the order, issued from Vienna, to restore the fortifications of Verona was (as appears from manuscript documents abandoned by the Austrians at Milan, when in 1848 they withdrew to the Adige) "to convert the city of Verona into a perfect fortress, to be made use of in the manœuvres of the imperial army, and to form a depôt for it," an order which was thus interpreted by the Austrian military engineers: "to give to this spacious fortress, besides a proper degree of solidity and defensive power, the means of favouring rapid movements of troops, so as to enable them after a defeat, to retire behind it to the left bank of the Adige; or, after a partial victory, to afford them bulwarks, behind which to wait till reinforced with fresh troops, they would be able to act on the offensive."

In consequence of this, General Scholl of the Engineers, proposed to execute a number of works, but in fact beyond the general restoration of the enciente, commenced in 1834, and which was given an essentially offensive character, no fortifications were undertaken for the time being, except those described below:

1. The hexagonal fort between the Adige and the Bastion of Spain, called the Fort of S. Procolo, designed specially to defend the bend of the Adige on the north side of the city.

2. A tenaille work on the left bank of the Adige, to cover the bridge of the Old Castle; this was probably demolished in 1854, when the construction of the Arsenal was decided upon.

3. The re-construction of the Castle of S. Felice on the existing ruins, the redoubt being rendered far stronger than it previously was. Having very good internal arrangements it is now one of the essential fortifications of the place.

4. The work called Gazzometro, in front of the cemetry, on the left bank of the Adige, with two tiers of guns, eleven casemates, an upper parapet and a keep.

5. The work, Biondella, in the neighbourhood of the Bastion of S. Toscana, for three guns in casemates, and two on the parapet.

6. The three forts, S. Sofia, S. Leonardo, and S. Mattia; and the four towers of S. Giuliano on the heights to then orht of the city, which surrounded the Donega Vale; the forts are situated on the western, and the towers on the eastern spur.

And here it will be useful to observe that General Scholl, besides these works, had proposed at the same time, and under the same circumstances:

1. That the brow or continuous ridge, semi-circular in form, and concave on the side of Verona, which extends from the neighbourhood of S. Lucia, to the other side of S. Massimo and Croce Bianca, as far as Chievo, might be advantageously strengthened with works.

2. That appropriate works should be constructed on the right bank of the Adige near S. Catterina.

The aim of these plans was, in the case of the former works, to prevent a powerful enemy from establishing with facility on this line, batteries, whence he might restrict any movement which might be undertaken from Verona on the right bank of the Adige; and in the case of the latter, to facilitate any advance of the imperial troops assembled in the lower space surrounded by the Adige. But owing, probably, to the great expense that such a system of fortifications would have entailed, both in the transportation and movement of earth, and in the exorbitant employment of artillery which it would necessitate, of all these last named fortifications not one was then executed.

With regard to the other works mentioned above, they were commenced in the year 1833, and finished in the year 1839. They may thus be said to have begun their history with the commencement of General Count Radetzky's command in Italy, who, in order to derive the greatest possible advantage from them in case of war, made Verona in peace time the centre of the Autumn manœuvres, thus offering his subordinate generals and other officers a favourable opportunity for studying the ground, for the just appreciation of which he had a military map made of the strip of ground between the Chievo and the Adige, on a scale of $\frac{1}{21600}$.

* * * * *

New Works constructed after 1848.

The campaign of 1848, having been concluded by an armistice at Milan, on the 5th August, the Austrian General, mindful of the 6th of May, a day, which in the last campaign had proved disastrous to Verona, and perfectly persuaded by the warlike preparations which continued to go on in Piedmont, that a second campaign would soon be undertaken, determined to do what fifteen years ago General Scholl had proposed, and repeatedly urged, viz., to make an entrenched camp in front of Verona, following the brow of the eminence which lies between Chievo, S. Massimo, and S. Lucia, and the salient angle made by the Adige at Tombetta.

But hostilities again commenced, and the second campaign was fought in very few days on the plains between the Ticino and the Sesia, and thus the new works (at that time in course of construction) remained, and still remain without baptism of fire, and therefore their efficacy awaits the confirmation of experience.

The following works were then commenced :

1. The Fort of Porta Nuova (formerly Clani): 70 men, 14 guns. Commenced immediately after the declaration of the armistice; it has a ditch, parapet, casemates on the flanks with three guns in each, a gorge wall with central caponier to hold four pieces, and an interior bombproof keep, finished in 1853. In 1859 a detached wall was constructed in the ditch, with two bomb-proof caponiers at the angles between the flanks and faces, and one at the centre of the front face, and corresponding galleries.

2. Fort Palio (formerly Alt-Wratislau): 60 men, 8 guns. It has a ditch, parapet, gorge-wall with central caponier and an interior bombproof keep, built between 1848 and 1850. In 1859 additions were made, similar to those described above, for the Fort of Porta Nuova,

3. Fort of S. Lucia (formerly Schwartzenberg): 60 men, 6 guns. In 1848, the ditch, parapet, gorge palisade, and a wooden barrack for the troops, were constructed. In 1859, the gorge was closed by a wall with a central caponier, and an interior masonry keep, a well and powder magazine, and a palisade at the foot of the escarp were added.

4. Fort Fenilone (formerly D'Aspre): 115 men, 17 guns. This work was constructed in 1848 and 1849. The gorge was closed with a palisade with a small central tambour. It has an interior, masonry, bombproof keep. In 1859, a detached wall was built in the ditch, with two caponiers, and corresponding galleries, as at the Fort of Porta Nuova, and the gorge was closed by a wall with a central caponier for two guns.

5. Fort S. Massimo (formerly Lichtenstein): 60 men, 14 guns. The works executed at this fort, both in 1848 and 1859, are similar to those of Fort S. Lucia.

6. Fort S. Zeno (formerly Radetzky): 60 men, 12 guns. This work was built in the years 1848, 1849, and 1850. It is closed, of polygonal trace, and has a bombproof keep. In 1859, a detached wall was added, with two covered caponiers in the front, and two open ones on the opposite face.

7. Fort of the Spianata (formerly Wallmoden). This is an earth battery constructed in the year 1848, nearly a kilometre in

rear of the forts of Croce Bianca, and of S. Zeno. It protects the fortress, and is in turn protected by it, and by the two above mentioned forts, and it bars the road leading from Croce Bianca.

8. Fort Tombetta (formerly Culoz): 60 men, 5 guns. Constructed in the year 1848. It consists of one tower, with two bombproof stories, and with a ditch round it.

9. Fort Chievo (formerly Kaiser Franz Joseph): 316 men, 17 guns. Completed in the 3 years, 1850, 1851, and 1852. It has a polygonal trace and detached wall, and 2 caponiers between faces and flanks, with 4 pieces in each. It is closed at the gorge by a tenaille wall, in the centre of which is a large tambour of two bombproof tiers, with 8 embrasures. There is a stone gallery, and a large keep with two tiers of guns.

10. Fort S. Catterina (formerly Hess): 600 men, 17 guns. The works, and the period of their construction, are as in the preceding case. In addition, there are two covered batteries at the flanks of the gorge.

11. Fort of Croce Bianca (formerly Strassoldo): 60 men, 12 guns. The works were executed in 1851 and 1859. They are similar to those of Porta Nuova; the gorge caponier has, however, only two pieces. To protect the eastern side of the fortress, which remained uncovered, the Austrians decided, in 1858, on the construction of a fort, astride the road leading to Vicenza, a little in advance of the parish of S. Michele, whose name it now bears.

12. Fort S. Michele (formerly Kaiserin Elisabeth): 200 men, 32 guns. Built in the years 1854, 1855, and 1856; like Fort Chievo, but with 4 caponiers, one at the gorge with five pieces, and two on each flank with two pieces each. The road makes a curve on the left of the fort.

New Works constructed after 1859.

In the year 1859, the Austrian Military Engineers, in addition to strengthening the already existing forts, building, as already mentioned, detached walls in their ditches, improving the condition of the gorges, &c., commenced the Fort of Parona on the right bank, to the north-east of Chievo and to the west of Parona, and on the left bank, to the north of S. Michele, the batteries of Montorio and of Preara; then, to increase the defensive value of the place on the south-west, they constructed the Forts of Lugagnano, Dossobuono, Azzano, and Tomba.

13. Fort Parona (formerly Albrecht): 250 men, 30 guns. Commenced in 1859, it was not yet finished in 1861. It has a

regular octagonal trace, surrounded by a ditch and detached wall. It has 4 caponiers of two pieces each, two galleries, and a large bombproof keep.

14. Fort of the Castle of Montorio: 60 men, 35 guns. This is a large battery closed by a wall having loopholes and embrasures.

15. Fort Preara (formerly John): 100 men, 14 guns. Constructed in 1859 and 1860. This is a closed battery with a ditch in front, excavated in the rock.

16. Fort Lugagnano (formerly Prinz Rudolph): 350 men, 17 guns. This is a closed work executed in 1860 and 1861. There are two caponiers at the angles, with spacious epaulments for four guns each. The gorge tambour has only one tier of guns. The other parts are like those of Fort Chievo.

17. Fort Dossobuono (formerly Gisella): 350 men, 17 guns. Similar to the preceding work, and built at the same time.

18. Fort Azzano (formerly Neu Wratislau): 210 men, 15 guns. Like the two preceding works.

19. Fort Tomba (formerly Stadion): 350 men, 17 guns. Like Azzano.

In 1866, the Austrian Engineers, turning their attention to the eastern side of the place which still remained weakly defended, constructed in great haste, in order to complete the exterior line of forts, the two works Citta Vecchia and Citta Bellina, the former on the right, and the latter on the left bank of the Adige; both planned by Colonel Tunkler. These two forts are recognized by Brialmont in his *Fortification à Fossés Secs*, as a good type of provisional fortification; he declares the ingenious dispositions of the engineer to be excellent, and especially the fact of his having established a subterranean communication between the ramparts of the gorge and those of the faces. The want of such communications in the forts round Paris was much felt at the time of the last siege. These forts, we may add, served with slight variations as models to the French Engineers, for the construction of the forts of Hautes Bruyères and of Montretout. The execution of Citta Vecchia required 25,974 days of soldiers' work, and 116,677 days of citizens' work. That of Citta Bellina 10,588 of the former, and 52,530 of the latter. The works were commenced on the 13th May, 1866, and finished in the first days of August.

20. Fort Citta Vecchia: 250 men, 24 guns.

21. Fort Citta Bellina: 200 men, 20 guns.

Finally, batteries were constructed at about the centre of the intervals between the more advanced works on both the right and left bank, and on the right of Fort S. Michele. In consequence of the successive additions to the fortifications erected round Verona, it now ranks among the vast and important fortresses of Europe. Its system may be considered as composed of three lines, one of which is an interior and continuous one, and the others exterior, and formed of detached works.

Interior Line.—In this is comprised the following works:—

On the right bank:

1. The Fort of S. Procolo, and the bastion fronts extending from the Bastion of Spain, where the river enters the city, to the Bastion of S. Francesco, where it leaves it.

On the left bank:

2. The Fort Gazzometro and the other bastion fronts, from Campofiore to S. Toscana. Both these and the preceding ones are in good condition.

3. The old walls of the Scaligers which enclose the upper part of the city from the Bastion S. Toscana as far as the Adige at the Porta S. Giorgio, and the Blockhouse of Biondella.

4. The Castle of S. Felice.

5. The Barracks of S. Pietro. In the small place in front of these barracks 8 to 10 pieces of artillery may be mounted *en barbette*.

Exterior Line.—This is composed of the following 12 works:

On the right bank:

1. Battery of the Spianata.
2. Fort of S. Zeno.
3. ,, of S. Massimo.
4. ,, Fenilone.
5. ,, of S. Lucia.
6. ,, Palio.
7. ,, of Porta Nuova.
8. ,, Tombetta.
9. ,, of S. Catterina.

On the left bank:

10. Fort S. Sofia.
11. ,, S. Leonardo.
12. ,, S. Mattia.

First Exterior Line.—This comprises the following works:

On the right bank:

1. Fort Parona.
2. ,, Chievo.

3. Fort Croce Bianca.
4. „ Lugagnano.
5. „ Dossobuono.
6. „ Azzano.
7. „ Tomba.
8. „ Citta Vecchia.

On the left bank:

9. Fort S. Michele.
10. „ Citta Bellina.
11. „ Montorio.
12. „ Preara.
13 to 16. The Towers of S. Giuliano, Nos. 1, 2, 3, & 4.

To these should be added the following batteries:

On the right bank:

Fenilone, Alberti, Torcolo, Legnago, and Palazzina, between the forts, Lugagnano, Dossobuono, Azzano, Tomba, and Citta Vecchia.

On the left bank:

Cosotti and Sandri, between the river and the Fort S. Michele.

Of these batteries, only the traces exist at the present time.

To complete the enumeration of the works constructed by the Austrians in this entrenched camp, the loopholed-wall surrounding the whole of the ground occupied by the works attached to the railway station at the Porta Vescovo should be mentioned. At the angles of this enclosure wall are small masonry tambours with embrasures.

General View of the Forts of Verona.

The limits of these notes will not permit of many details; we may however mention that these forts of Verona belong to the polygonal system, and that, with their various forms, each improving on the other, they represent the stages through which this system of fortification has passed during the last forty years. Thus they cannot be divided into special groups; it can only be said that while the two last works, Citta Bellina and Citta Vecchia, are of a provisional nature, the others are all of a permanent character. The batteries between the forts of the first line, were purely field works.

General Remarks on the Entrenched Camp of Verona.

This entrenched camp of Verona, which was the dreaded bulwarks of the Austrian power in Italy, this corner stone of the famous quadrilateral, this key of the Adige, the object of so much study to the soldiers of Austria, was very differently valued by the Austrians themselves. It is no secret that different opinions on it were entertained by the staff and the military engineers. The best plans and suggestions concerning it seem to have been those of the Engineer Scholl, which Marshall Radetzky had partially carried out, but only after fifteen years had elapsed, and after he had witnessed the standard of Charles Albert float above the walls of Verona. Then recently again, Colonel Tunkler assisted to complete on the eastern side, the design of General Scholl.

Finally, in 1866, Verona with its sister Venice, came to form part of the great Italian family, and its entrenched camp has been criticised in different ways and from opposite points of view by Italian writers and authorities on military subjects. Much, perhaps too much, has been written on Italian military affairs, and also about this camp of Verona. The suggestions, however, concerning it, which have deservedly made great impression on the country, owing to their completeness, diversity, and the authority of their authors, are those of the suppressed Permanent Commission for the Defence of the State, and those of the Signor Relatore at the Chamber of Deputies.

Truly does the sword of Damocles hang over Verona's entrenched camp. Will the thread break, that holds it?

M.N.

PAPER XII.

ACCOUNT OF THE GEOGRAPHICAL OPERATIONS IN AFGHANISTAN 1878-80.

BY LIEUT.-GENERAL J. T. WALKER, C.B., F.R.S., ROYAL ENGINEERS,
SURVEYOR GENERAL OF INDIA.

Extract from the General Report on the Operations of the Survey in India during 1878-79.

THE extension of our geographical knowledge of Afghanistan, and the rectifications of the hurried surveys which had been made during the first Afghan war, but had never been properly combined together, have long been desiderata of great importance. So long, however, as it was the policy of the Government to prevent any attempt being made to survey regions beyond the British frontier, and even to discourage Survey Officers from pushing their operations up to the frontier, in order to avoid any risk of collision with the independent tribes beyond, it was impossible for the Survey Officers to do more than fix all the most prominent points on the hill ranges beyond, which were visible from the trigonometrical stations within the frontier, and to fill up the details of the country from native information, or by the secret agency of native explorers. In the summer of 1878 there was reason to expect that the time-honoured policy of "masterly inactivity" would shortly be departed from, and that the frontier line was no longer to be regarded as an impassable barrier to geographical research. Arrangements were being made for a force to proceed, under General Roberts, into the hill country between Quetta and Dera Ghazi Khan; and Captain Woodthorpe, R.E., was to have been attached to the staff of General

Roberts, with a view to making the most of any opportunities which might arise for survey operations, at any point along the entire length of the frontier line between the British territories and Afghanistan.

These arrangements had soon, however, to be changed into others for a more general and extended survey, which became possible when war was declared with the Amir of Afghanistan, and his kingdom was invaded at several points by our armies. A Survey Officer was then attached to each of the four columns which were formed, two to operate in Southern and two in Northern Afghanistan; but in a short time it was found necessary to treble the number of these officers, in order to meet demands from the Military and Foreign Departments and from the Commander-in-Chief, for a further extension of the survey operations.

It will be convenient to divide the operations into the three folling groups, for description, *viz.*, 1st, those in Southern Afghanistan, with the columns under the command of Generals Stewart and Biddulph; 2nd, those in the Kuram Valley, and generally to the south of the Safed-Koh range, with the column under General Roberts; and 3rd, those in the Kabul Valley, and generally to the north of the Safed-Koh range, with the column under General Sir S. Browne.

I.—The Operations in Southern Afghanistan.

Personnel.

Major (now Lieutenant-Colonel) W. M. Campbell, R.E., Deputy Superintendent, 2nd grade.
Captain W. J. Heaviside, R.E., Deputy Superintendent, 3rd grade.
Captain T. H. Holdich, R.E., Assistant Superintendent, 1st grade.
Captain M. W. Rogers, R.E., Assistant Superintendent, 1st grade.
Captain R. Beavan, S.C., Assistant Superintendent, 2nd grade.
Lieutenant St. G. C. Gore, R.E., Assistant Superintendent, 3rd grade.
Lieutenant J. R. Hobday, S.C., Assistant Superintendent, 3rd grade.

In October 1878, Captain Rogers, R.E., was posted to General Biddulph's column which had been ordered to be formed at Quetta, and Captain Beavan to General Stewart's column which was being formed at Multan. It was expected that the Multan column would advance on Quetta by the direct, but as yet untried and unsurveyed, route crossing the Sulimani range; while the portion of General Biddulph's column which was being sent from India would march on Quetta by the route *viâ* Dera-Bugti and Lehri, on the frontier between Upper Sind and Beluchistan, to the entrance to the Bolan Pass. Captain Rogers being much delayed and hindered on his way to join the army, Captain Beavan, who had a shorter distance to travel, arrived first and joined General Biddulph's column. Captain Rogers accompanied the Multan column, which had eventually to be marched on Quetta by the circuitous but well known route *viâ* Sukkur and Jacobabad. Captain Heaviside, R.E., who was then returning from furlough, and Captain Holdich and Lieutenant Hobday, who were in England, were ordered by telegram to proceed to Quetta without delay: the former arrived there on the 8th January and the two latter on the 18th February. Lieutenant Gore, R.E., was transferred from the Guzerat Survey on the 3rd January and reached Quetta on 13th February. Finally, Major Campbell, R.E., who had arrived at Bombay on his return from furlough to Europe and Australia on the 5th February, was also sent to Quetta, were he arrived on the 20th March.

Each of these officers was provided with as complete an outfit of instruments as the sudden demand admitted of, to enable him to execute any work that might be required of him, in the shape of route surveying, sketching with the plane-table, triangulation, or astronomical observation. A few native surveyors were attached to the force, and each officer had authority to entertain as many men as might be required to carry his instruments and render any other necessary services, engaging them on the spot or getting them from India, as might be most feasible.

Captain Beavan carried route surveys from a trigonometrical station on the frontier near Kusmore, along the Dera-Bugti road as far as Lehri, from the foot of the Bolan Pass to within a short distance of Quetta, and from Quetta to Kandahar *viâ* Gulistan Karez, the Khojak Pass, and Chaman. He then accompanied General Biddulph's force to Girishk, surveying the line of road and also as much of the country around Girishk as his opportunities allowed. On returning to Kandahar, he was employed with other officers in making a survey of the country around Kandahar, within a radius of twelve miles, on the scale of one inch to the mile. In August he was employed in attempting to extend his route survey between Kandahar and Chaman into the country on either side, but was prevented from doing much by the very unfavourable condition of the atmosphere and by ill-health. He was subsequently sent to Sibi, where he is still employed.

Captain Rogers carried a route survey from Quetta to Kandahar *viâ* Gulistan Karez and the Gwaja Pass through the Khwaja Amran range. While General Stewart's column was halting in Pishin, he ascended the highest peaks of the range with a theodolite, and took observations to a number of points on the northern side of the range and towards Kandahar, which afterwards proved of much value when supplemented by corresponding observations at Kandahar. He accompanied a force which marched from Kandahar to Kalat-i-Ghilzai by the direct route and returned by the Arghandab Valley, surveying both routes and giving out triangulations on which reconnaissances were based by Captain Sartorius of the 59th Foot, and Lieutenant Olivier, R.E., whose services had been made temporarily available for the survey operations. Returning to Kandahar in February, he was first employed by the General in command in compiling a map of the work already done, and then in aiding the general survey of the country immediately around Kandahar. During the hot weather he accompanied an expedition to the Khakrez Valley to the north-west; he also took a share in the requisite observations for determining the difference of longitude between Kandahar and Quetta, electro-telegraphically, Major Campbell taking the simultaneous observations at Quetta. In the middle of August he left Kandahar to return to India, with special instructions to strengthen and complete the triangulation down to the points at Quetta. Although the weather was very much against him, owing to great heat and continual dense haze, he persevered with the work and finally succeeded in completing it.*

Captain Heaviside carried a route survey with a prismatic compass and perambulator from Quetta to Kandahar, checked by latitude observations at Gulistan Karez, Chaman, and Abdul Rahman. He was then employed in commencing a survey of the Kadanai Districts lying to the north-east of the Khwaja Amran range, in which he was eventually joined by Captain Holdich; and from that time onwards these two officers worked together, the former measuring base lines, triangulating, and taking check observations for latitude and azimuth; the latter sketching all the ground visible from the hills to which access could be obtained, on the geographical scale of $\frac{1}{4}$ inch to the mile.

In the month of March, while still at work in the Kadanai District, Captains Heaviside and Holdich received instructions to join the column under General Biddulph, which was under orders to return to India by a new and unexplored route—the one by

* Major Campbell reports that Captain Rogers had a most arduous year's work, with a greater share than most officers of all the hardships of the campaign, including all vicissitudes of cold and heat, and he deserves great credit for the energy with which he went through it.

which the Multan column was originally intended to have entered Afghanistan. They therefore recrossed the Khojak Pass, and surveyed along the southern edge of the Khwaja Amran range to Balozai, the appointed place of rendezvous, where a halt of three or four days fortunately afforded time for the measurement of a base-line, the determination of its azimuth, and the execution of some triangulation connecting with Captain Rogers's points, which proved to be of much value in the subsequent operations. The march was commenced on the 24th March, and was executed at the average rate of 12 miles a day, some of the marches being over 20 miles in length. Fort Munro, on the British frontier, was reached on the 17th of April. The route lay through the Bori, Luni, Chamalang, and Kaho valleys, crossing several mountain passes and passing the important villages of Tal and Chotiali, which has led to its being called the Tal-Chotiali route. The rapidity with which the force marched made it impossible to carry a continuous triangulation across the entire breadth of country; thus after a while Captain Holdich was dependent on his plane table alone, without any extraneous assistance; but on reaching the Sulimani range he met with the trigonometrically-fixed points of the surveys on the Indus, and his connection with these points sufficed to show that, rapidly as his work had been executed and in parts without any extraneous assistance, it was as accurate as could be desired for a survey on the $\frac{1}{4}$ inch scale. From first to last it embraced an area of about 5,000 square miles.

Lieutenant Gore had been specially deputed to Quetta in order to make a survey of the Pishin Valley for the Foreign Department. After consultation with the political officers, he decided that the $\frac{1}{2}$-inch scale would be the most suitable for the requirements of the authorities, as regards the amount of detail to be shown and the speedy production of a map of the country. Measuring a base-line in Gulistan, he carried on the necessary triangulation and plane-tabling single handed, connecting the former as soon as practicable with the triangulation which had been brought up from Sind. He also accompanied an exploring party under Captain Wylie over the Toba plateau, and another under Captain Showers round the east and north boundaries of Pishin, and across a tract of new country stretching from Quetta into the Kadanai plains. He had a very hard season's work, continued without a break throughout the hot weather, and his outturn is excellent both in quality and quantity, and has been highly commended by General Sir D. Stewart.

Lieutenant Hobday carried a route survey from Chaman to Kandahar, diverging whenever practicable from the line taken by his predecessors. He took a large share in the survey operations near Kandahar, including the large-scale survey of the surrounding country and the reconnaissance of the Khakrez Valley. He was much occupied in teaching the use of the plane-table to certain officers who had been temporarily withdrawn from regimental duty to assist in the survey operations. But severe attacks of fever obliged him to abandon field work and go into recess quarters in June. Returning towards India with a portion of the force in August, he was again attacked by fever, but succeeded in making a large-scale survey of the Khojak Pass, during an unusually protracted halt in the neighbourhood. He was shortly afterwards sent to Europe on medical certificate.

Major (now Lieutenent-Colonel) Campbell was directed on reaching Quetta to assume general charge of the operations, as the senior Survey Officer in Southern Afghanistan, and to be specially on the look-out to make arrangements with the military and political authorities to make the most of every opportunity which might arise for extending our geographical knowledge. At first he availed himself of an opportunity of visiting the plains of Shoráwak, with a detachment sent there from Gulistan Karez, and he made a route-survey of about 150 miles, closing on Quetta, through new country between Pishin and the great central desert of Afghanistan. He then took observations at Quetta for determining the difference of longitude between that place and Kandahar by means of the newly established electro-telegraph line, Captain Rogers co-operating at the Kandahar end. Leaving Quetta on the 8th May, he accompanied the Political Officer, Captain Wylie, and Lieutenant Gore on a trip for the exploration of the hitherto almost unknown table-land of Toba, which was most successful, crossing the plateau in three directions, and thus permitting of the construction of a really good map. He wrote a report of the country which has been printed in the Quarter Master General's Department. Descending from Toba, the party went to Gulistan Karez, where there happened to be a telegraph station. Major Campbell therefore availed himself thereof to determine the difference of longitude with Kandahar electro-telegraphically a second time, Captain Rogers again co-operating at Kandahar.*

* Major Campbell reports that the two values of the longitude of Kandahar, as referred by these measurements to the origin of the Great Trigonometrical Survey, agree fairly well, and assign a position to Kandahar which is within a quarter of a mile of the position afterwards deduced on the completion of the triangulation between Kandahar and Quetta. This is as follows:—Trigonometrical station on highest building in Kandahar citadel, near the centre, 65° 45′ 2″ east of Greenwich; a correction of *minus* 2′ 30″ is necessary to reduce this value to the latest value of the longitude of the Madras observatory, which is the origin of the Indian triangulation.

He then proceeded northwards, taking the route by the Barghana pass, and eventually arrived at Kandahar on the 22nd June, where he took charge of the survey offices and the work of calculations and mapping which remained to be completed. The whole of the maps were submitted in due course to General Sir D. Stewart for approval and transmission to the Commander-in-Chief. On the renewal of hostilities in October, Major Campbell accompanied the force under Brigadier-General Hughes to Kalat-i-Ghilzai, and returned with it to Kandahar in the following month, when, finding that there was no prospect of furthur survey work until after the winter, he applied for and obtained permission to return to India.

Captain Sartorious of the 59th Regiment, Lieutenants Small and Lake of the same regiment, Lieutenant Baynes of the 60th Rifles, and Lieutenant Olivier of the Royal Engineers, were temporarily employed in the survey operations around Kandahar, and rendered much valuable assistance. Major Campbell specially notices the excellent work done by Captain Sartorius, who is as skilful a draftsman as he was subsequently proved to be a swordsman, in an action with the enemy, when his gallant conduct was the admiration of all eye-witnesses. Captain Maitland, of the 3rd Sind Horse, was also on survey duty for a short time in Pishin, with Major Campbell.

II.—The Operations in the Kuram Valley, and generally to the south of the Safed-Koh Range.

Personnel.

Captain R. G. Woodthorp, R.E., Assistant Superintendent, 2nd Grade.
Captain Gerald Martin, Assistant Superintendent, 3rd grade.

Doing Duty.

Lieutenant Manners Smith, Adjutant, 3rd Sikh Regiment.

When the arrangements alluded to, (see page 206) fell through in consequence of the war with Afghanistan, Captain (now Brevet-Major) Woodthorpe was attached (with a native surveyor) to the Kuram Column, under General (now Sir) F. Roberts. For four months he was the only officer of the Survey Department serving with the column; but he was aided by Lieutenant Manners Smith, of the Panjab Frontier Force, whose services had been placed at the disposal of General Roberts for survey work. In March 1879, Captain Gerald Martin joined the survey.

Captain Woodthorpe accompanied the first advance of General Roberts' force to the Peiwar in November, 1878, partly along the right (south) bank of the Kuram River, *viâ* Hazir Pir and the Darwaza Pass, and he plane-tabled the country along the route. He was present at, and took part in the military operations of the 28th November and of the 2nd and 3rd December; and he had a marvellously narrow escape during the action of the 2nd, when, in the dusk of the morning, he went up by mistake to a breastwork occupied by the enemy, who did not discover his presence till he was within six yards, when they fired a volley at him. The stock of his pistol was smashed by a bullet which grazed his side, and drove a piece of his clothes into his sketch-book, which was considerably damaged; but he himself escaped uninjured.

He completed a reconnaissance, on a large scale, of the scene of action; and on the advance of the force he plane-tabled from the Peiwar along the Ariob* Valley through Ali Kheyl to Rokian, from which point, owing to the narrowness of the valley and his inability to visit points affording a good view on either flank, he was only able to carry a route-survey to the Shutargardan Pass. He found the position of this pass to be considerably erroneous on the old maps. On his return to Ali Kheyl he visited the Matungeh hill,† about 4½ miles north of Ali Kheyl, and accompanied the reconnaissance in force, through Chapri and Karai in the Mangal country, to Kuram.

In January he accompanied the expedition into the Khost Valley *viâ* Jagi-Maidan, Bahok, and Akubi to Matun, and explored the valley to the west, in the direction of Degan and Ismail Kheyl. During this expedition nearly the whole of Khost was mapped. The Shobakgarh range, between the Kuram River and Khost, was subsequently visited, and the position of the pass over the range into Khost was fixed; a route survey of the new road from Ibramzai near the confluence of the Kuram and Karmana Rivers, *viâ* Hazar-Pir, to Thal, was also completed.

In the month of March Captain Woodthorpe visited the hill of Matungeh for a second time, accompanied by Captain Martin. They obtained a good view of the country towards Ghazni, and, notwithstanding the inclemency of the weather, were able to complete a good deal of work. They also visited the Lakarai Pass leading from Ali Kheyl *viâ* the Surkhab Valley towards Gandamak, and sketched portions of the Tezin and Jagdalak hills, otherwise known as the Karkacha range. During May, reconnaissances were

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* Captain Gerald Martin states that hitherto this name has erroneously been written "Hariob."

† About 12,900 feet above sea-level.

made to the Sirkai and Shutargardan Passes; to the Tarazod peak near the Mangior Pass; to the Istar Pass and head of the Mangior defile, looking over the Ahmed Kheyl country; to the Kafartaga hill and to the Naktek peak over the Ahmed Kheyl and Lajji country, during which the positions of the Ahmed Kheyl and Lajji villages were fixed, and a good deal of the topography south and west of Ali Kheyl was completed.

Subsequently Captains Woodthorpe and Martin visited Sikaram, the highest peak on the Safed-Koh range (which had already been ascended from the Jalalabad side by Mr. Scott), with a hope of being able to take observations, from it and other points on the crest of this range, to the peaks of the Hindu-Kush range; unfortunately, however, the condition of the atmosphere was unfavourable for such observations, the hot weather haze having set in, which shut out all view of far distant ranges.

The limits of the survey approximately are, to the east, a line drawn from Thal on the Kuram River to the Agram Pass on the Safed-Koh range; to the north, from the Agram Pass along the Safed Koh to the Shutargardan Pass; on the west, the water-parting beyond the basins of the Kuram and the Khost Valleys; on the south, the range which forms the southern watershed of Khost. The total area mapped covers about 3,000 square miles. The scales of survey adopted were 1 inch to the mile for routes, and $\frac{1}{4}$ inch to the mile for the geographical work.*

On the conclusion of the Treaty of Gandamak, Captains Woodthorpe and Martin proceeded to the survey head-quarters at Mussuri to complete the mapping; but they had not been there more than a few weeks when they were ordered to return to Kuram, to join Sir F. Roberts in his advance on Kabul. Their subsequent operations form a part of those to be described in the report for next year. Both officers have done much good work. Lieutenant Manners Smith rendered valuable assistance in route surveys, military sketches, and mapping, while attached to the survey party.

* Captain Woodthorpe reports that the old map of the Kuram Valley[1] is exceedingly accurate as far as the Peiwar Kotal on the north bank of the river, but he has been able to improve it a little. An interesting narrative of the events connected with these operations, and a general description of the country and its inhabitants, was contributed by Lieutenant Gerald Martin to the October number for 1879, of the "Proceedings of the Royal Geographical Society, London."[2]

[1] By Lieutenants Garnet, R.E., and P. Lumsden, 1857.

[2] See also a paper contributed by Major J. Waterhouse, Assistant Surveyor General, to the Journal, Asiatic Society, Bengal, Vol., XLVIII, Part II, 1879.

Captain Woodthorpe's very valuable and varied services have been suitably recognised by his promotion to a brevet-majority.

III.—The Operations in the Valley of the Kabul River, and generally to the north of the Safed Koh Range.

Personnel.

Major H. C. B. Tanner, S.C., Deputy Superintendent, 3rd grade.
Captain C. Strahan, R.E., Deputy Superintendent, 3rd grade.
Captain E. W. Samuells, Assistant Superintendent, 1st grade.
Captain E. P. Leach, R.E., Assistant Superintendent, 2nd grade.
Mr. G. B. Scott, Surveyor, 3rd grade.

On the formation of the Peshawar column, under General Sir Samuel Browne, in November, 1878, Major (now Lieutenant-Colonel) Tanner, Captain Samuells, and Mr. Scott, were attached to the column. Captain Leach, R.E., joined it in the following month of January, and Captain Strahan, R.E., in April.

Each of the first three officers accompanied one of the three divisions which advanced from Jamrud on Ali Masjid by different routes, at the commencement of the campaign. Captain Samuells much distinguished himself by carrying on his plane-tabling under a heavy fire; but, unhappily, he shortly afterwards fell a victim to typhoid fever, and was brought back to Peshawar, to die there on 21st December.

Major Tanner carried a continuous route survey from Ali Masjid to Jalalabad, reconnoitring the ground on each side as far as was practicable. He also measured base-lines and executed triangulations, combined with astronomical determinations of latitude and azimuth at Dakka and Jalalabad. He took a number of observations to the peaks of the surrounding hill ranges, both north and south of the Kabul River; fortunately he soon discovered that several of his points were identical with points which had been fixed several years previously by Captain Carter and other officers, in the course of the operations of the Great Trigonometrical Survey on the Trans-Indus frontier. Thus, though it had not been possible to carry up a triangulation from the British border, these indentified points became a basis for the survey operations, enabling them to rest everywhere on triangulation, and be made independent of further astronomical observations. Jalalabad, when connected with them, was found to be about 5 miles nearer to Peshawar than has hitherto been accepted, on the authority of the maps and surveys of former times.

In May, Major Tanner undertook an exploration into Kafiristan through the Kunar Valley and Chuganistan, and after several perilous adventures reached Aret; but there, owing to the hardships and exposures incidental to the undertaking, his health failed, and prostrated by fever, he was compelled to abandon his design and return to Jalalabad, which he was able to do through the friendly aid of the Chugani Chief, Azim Khan, and the Malik of Jinjapur.

Captain Leach joined the force in January, and during the two months he was at work, surveyed a good portion of the Bazar Valley and the country round Jalalabad, chiefly in the Shinwari country and on the northern slopes of the Safed-Koh range. At the end of March he was compelled to withdraw from all active share in the operations, in consequence of a severe wound received during an attack on his party by Shinwaris, near the villages of Maidanak and Girdi; his gallantry has won for him the honoured distinction of the Victoria Cross.

Captain Charles Strahan joined early in April, *vice* Captain Leach. He executed a survey of the country between Safed Sang and Surkpul, and about 80 square miles north of the road up to the Surkhab River; he also made a rough sketch of the Siah-Koh beyond, up to the crest of the first range; and subsequently he was able to visit the Siah-Koh, and complete some useful observations to peaks on the Hindu-Kush and in Kafiristan. From and around Safed Sang he fixed by triangulation nearly all the prominent peaks visible on the Safed-Koh and Siah-Koh ranges, and some on the Karkacha range to the west, which will be most useful for the extension of survey operations towards Tezin and Kabul.

Mr. G. B. Scott made a variety of sketches on the scale of two inches to the mile, in the country to the south of the Kabul River, and between Jamrud and Dakka, in the Bazar Valley and in the Shinwari country. In February he was surveying a new route on the north bank of the Kabul River, accompanied by a small escort, when he was attacked by a strong party of Mohmunds, and a hand-to-hand fight ensued in which he desplayed great gallantry and good judgment, thereby probably saving his whole party from destruction. Later on, during the prolonged halt at Jalalabad, Mr. Scott visited the peak of Sikaram (Sikkarram),* the highest point on the Safed-Koh range, where he obtained observations to distant peaks all round, including a very prominent peak to the north, which he describes as "a pyramid standing far above the heads of

* Also called Said Karrambaba-ka Ziarat.

all the surrounding peaks of the Hindu-Kush." These observations will be very useful when they can be supplemented by corresponding observations from other stations.

The work completed in this section of the operations falls between latitude 33° 55′ to 34° 30′, and longitude 69° 45′ to 71° 30′. It covers an area of about 2,200 square miles, and extends from Forts Michni and Jamrud on the British frontier near Peshawar, to the Surkhab River west of Gandamak, including a little of the northern and most of the southern portion of the basin of the Kabul River. On the northern slopes of the Safed-Koh, in the country of the Shinwaris and Khagianis, some blanks remain, which were unavoidable owing to the conditions under which the survey in an enemy's country was conducted.

A considerable amount of valuable geographical information was also obtained to the north of Jalalabad, in the Dasht-i-Gumberi plain and the Lughman valley, from the Daronta Pass to the junction of the Alishang and Alingar Rivers; and a more extended sketch, based upon triangulation, was obtained of the surrounding heads and hills of the above river valleys and extending westward to the Badpukt and Tang-i-Shaidan Passes. Mr. G. B. Scott was also able to compile a fairly useful map of Tirah, chiefly from native information based on points fixed by the triangulation.

IV.—Report on the experience gained regarding the sufficiency of the general organisation of the Survey Operations during the Campaign in Afghanistan.

The Secretary of State for India has intimated a desire that the experience gained during the recent campaign on the work and organisation of the several departments engaged, directly or indirectly, on the conduct of the campaign, shall be reported on and recorded, "both as regards those measures which on trial have failed, and those which have succeeded," in order that what has already been gained at great cost will not have to be re-bought, should an army be required again to take the field under similar circumstances. The present appears to be a suitable place for recording this information, as regards the Survey Department.

The only measure which can really be said to have been "on trial," as regards the survey operations, was the proper equipment of a number of officers, suddenly collected together from various parts of India, and even from England, for the duties which they might be expected to perform. In a few instances it was possible to send officers directly from head-quarters or from survey parties to join the army, with an equipment of men and instruments selected by themselves. But in a majority of instances it was not possible to do so, as when officers were summoned out from England, or sent up from parts of India at a considerable distance from the frontier; it was then necessary to send instruments, and a few native surveyors and khalasees collected from the nearest survey parties, to meet these officers at some point on the frontier—as Sukkur, Multan, or Peshawar—to which they were required to proceed by the shortest possible routes from the places where they received their orders to join the army. The officers who were in a position to select their own men and instruments, appear to have been fully satisfied with their own arrangements, as was but natural. Of the remaining officers, none has had any fault, worth mentioning, to find with the instrumental equipment which had been provided for him, with the exception of a single officer, who has reported that if he had not succeeded in securing a spare set of instruments which had been sent up and arrived in good condition, he would have been unable to do anything, as the instruments sent for himself proved on arrival to be unserviceable.

As regards the equipment of native surveyors and men, an equal amount of satisfaction has not been expressed. Some officers appear to have almost expected that they would find a complete and well-organised survey party ready to meet them the moment they reached the frontier, and to accompany them into the enemy's country beyond. But to arrange for the formation of such parties was impossible during the short time available; for the whole of the subordinates of the survey establishments, both Europeans and Natives, are civilians; and though many of them would gladly volunteer to serve in an enemy's country, none could be expected to go there as a matter of course. Moreover, isolated Hindustanis run a very great risk of being murdered in Afghanistan; thus it seemed desirable for each officer to entertain Pathans, Belúchis, or natives of the country on the border—to be employed as instrument-carriers, and generally in the menial operations of the survey—and not to take more Hindustanis with him than was essentially necessary, in order to secure the assistance of a few trained hands. Little difficulty appears to have been experienced in entertaining as many men of the border as were wanted, on the high wages then being given to camp followers; but it appears from the reports which have been received, that only a few of the officers were satisfied with these men; the majority would have preferred employing trained Hindustanis.

The native surveyors who were sent to Afghanistan were mostly men who could traverse with the theodolite and chain; they were found serviceable in carrying route-surveys along the lines marched over by the troops, while their officers diverged to the right and left, and sketched as much of the country as they could get sight of. This was what they were chiefly intended to do. Some disappointment has, however, been felt at the small proportion of these men who could sketch with a plane-table, write English, and compute skilfully; but the number of natives in the survey department who possess all those qualifications is very small, and it would have been scarcely possible to send more of them to join the army than actually were sent. As already observed, none of them are bound to serve beyond the frontier; and though natives of Hindustan will willingly accompany any European officer whom they know, and can trust to look after their welfare and interests, wherever he may happen to be sent, they will not readily volunteer to serve in an enemy's country under officers whom they have never seen, and of whom they know nothing.

Thus the lesson to be drawn from the experience of the past, is that officers of the Survey Department, when about to be sent to join an army in the field, should, if possible, be given sufficient time beforehand to select their own instruments and men, the latter more particularly, so that they may start fully equipped with all they require, instead of having to depend on instruments which may have to be sent to them from a great distance, and on men collected at haphazard from various quarters. Still, however, the late campaign has abundantly shown that much excellent work has been done by officers who have not possessed these advantages, but have raced to the front as fast as they possibly could go, picking up men and instruments, camp equipage and horses, wherever they could find them on the road, and depending on the natives of the border—and even of the invaded country—to supply deficiencies in the personnel of their parties.

So much for the only measure which may be said to have been "on trial." There are, however, other points which are familar to the officers of the Indian Survey Department, but are less well known in the army generally, which may be here noticed.

The duty of a survey officer, campaigning with an army in a comparatively unknown country, is to obtain general geographical information over as wide an area as possible, as well as to execute a minute and exact survey of the lines of route followed by the troops to which he may happen to be attached. When the troops march with great rapidity, it is impossible to do more than make a continuous survey of the route, excepting under very favourable conditions in the lie and general configuration of the ground, giving commanding points within easy reach of the line of route. When the troops halt anywhere for a few days, frequent opportunities of reconnoitring the surrounding country may occur, which it will be desirable to make the most of, not only for geographical considerations, but with a view to subsequent military operations.

The instrument *par excellence* for such work is the plane-table, either in the form in which it is so extensively used in almost all survey operations in India, or in a modified form giving greater lightness and portability, and yet retaining the special characteristic of the instrument in enabling the ground to be mapped on the spot, under direct ocular evidence, instead of elsewhere, on the evidence of observations recorded in note-books. If a good plane-tabler is given a base to start from, of which the length and azimuth are correctly known, and ground to operate in, with a fair proportion of commanding positions and hill peaks which are susceptible of ready identification, he can survey with great rapidity; first, fixing new points, should this not have been done for him beforehand, by triangulation; then using these points in their turn to fix his forward positions, and from them again fixing other points, and so on, until he has laid down all the surrounding country, to a distance much beyond the positions which he may have been actually able to reach. Thus it will be seen that a plane-table is a most valuable and necessary adjunct to the instrumental equipment of a survey officer attached to an army.

When the troops march very rapidly, and the route lies through a country which is flat and devoid of commanding positions, or in valleys which are hemmed in by inaccessible hills, or in tracts of forest, the plane-table is at a disadvantage as compared with the theodolite; for, in such circumstances, the usual method of route-surveying with a theodolite and chain or perambulator, or with a subtense instrument, and recording the observations on the spot and subsequently working out the results, either by calculation or protraction, may be expected to give a better and more accurate route-survey than would be got by plane-tabling.

There will be more or less of liability to error in all survey operations which are conducted with great rapidity, as presupposed above, both for the plane-table and the theodolite surveys; it is therefore desirable to check the operations from time to time by astronomical observations of latitude and azimuth; also by absolute longitude observations as well, whenever the troops are encamped long enough at any place to permit a sufficient number of observations being taken; or, better still, by differential longitudes, determined electro-telegraphically, whenever a line of telegraph has been established with the army. Thus the survey officer with an army should be supplied with a suitable instrument to enable him to take astronomical observations for the determination of latitude, azimuth, time, and longitude.

For this reason, several of the survey officers in Afghanistan were supplied with a 6-inch transit theodolite—an instrument which has a complete vertical circle, and an eye-piece fitted with a pair of "subtense micrometers," which are intended to measure small angles subtended by distant objects in the field of the telescope. It is described in General Thuillier's "Manual of Survey for India" (3rd edition, page 132); also in "Hints to Travellers" by the Royal Geographical Society, 4th edition, page 33. It may be called a universal instrument; for it is not only well fitted for astronomical observations, as well as the ordinary measurement of horizontal angles, but it enables the distances of objects of known length to be determined very readily, with the aid of the subtense micrometers, thus permitting measuring chains to be dispensed with in running traverses and measuring base-lines. It requires delicate manipulation, but in skilful hands it is capable of yielding admirable results. It weighs 31 lbs. when packed in its box, the stand weighing 10 lbs. more, and it is probly the lightest instrument yet constructed which is capable of such universal application.

A few 4-inch and 5-inch theodolites were also supplied; the former are particularly useful when a very light and handy instrument is required, which can be carried about on horseback; for their weight, when packed, is less than 15 lbs., and they pack into a small box.

The plane-tables were of the ordinary pattern and size, 30″ by 24″, as constructed in the Mathematical Instrument Department at Calcutta, with magnetic compasses, sight rules, and tripod stands. Their weight is nearly as follows:—

Plane-table	11 lbs.
Sight rule and magnetic needle	2 „
Tripod stand, folding 8 lbs., or braced ...	12 „

For a full description of the instrument, see pages xxiii. and xxiv.

of the Appendix to General Thuillier's "Manual of Survey," 3rd edition. Its weight and bulk are its only objection, as it cannot be conveniently carried about by less than two men, one for the table, the other for the stand; but our officers appear to have succeeded in getting their plane-tables taken up to every point, however high and difficult of access, which was reached by themselves during the campaign. The paper is mounted on the table; but by employing paper which is mounted on strong cloth and may be rolled up without injury, and pinning the portion which is being drawn on, down to the table, much smaller tables may be used, thereby materially diminishing the weight, and larger sheets of paper could be employed, which would sometimes be found an advantage.

The amount of clerical work which had to be done by the survey officers, in the preparation of bills of all kinds and indents for carriage and rations, was occasionally found to be very trying and to interfere greatly with their ordinary work. Making copies of their surveys as fast as completed, for the use of the military and political authorities, and for the Surveyor General's Office, was also found to be a great and serious tax on their time. A light and portable machine for reproducing maps would have been invaluable to each officer, and enquiries and experiments are now being made with a view to producing something of the kind, which may be of service hereafter. It is desirable that every survey officer should, whenever possible, have the assistance of a native surveyor or draftsman to make tracings of his maps and perform all such clerical work as may be wanted.

It may be added that an officer requires to be well skilled in each of the several branches of survey operation, in order that he may be in a position to make the most of all the opportunities which will be afforded him of achieving a survey of an enemy's country. He should be fertile in expedients for carrying on his work, without material error, whenever any breaks of continuity occur in consequence of the rapidity of the movements of the force which he is accompanying. He should be a good practical astronomer, a good computer, a good observer, and a good draftsman. In the ordinary routine of work in the Survey Department, there is a division of labour, of which the result is that an officer may become highly efficient in certain portions of the survey operations, and yet know nothing practically of the others, because he has not had, and is unlikely to have, any call or occasion to undertake them. Thus the officers selected for the survey operations in Afghanistan were chosen in equal proportions from the three branches—the Trigonometrical, the Topographical, and the Revenue—of the Survey Department, in order that some officer might be present, with each column, who would be qualified for at least one if not more of the operations—astronomical observation, triangulation, route-surveying, and topographical plane-tabling—which might be required at any moment. The conjoint operations of these officers have furnished results which may be pronounced decidedly satisfactory, in quantity as well as quality, considering the manifold difficulties under which they were accomplished.

Extract from the General Report on the Operations of the Survey in India during 1879-80.

The officers who had operated with the army in Northern Afghanistan, during the first year of the war, were withdrawn from the field when the army retired on the conclusion of the Treaty of Gandamak, and were occupied in bringing up their calculations and and completing their maps at the Mussuri head-quarters, when intelligence was received in September, 1879, that an army would at once be sent to Kabul, in consequence of the massacre of the British embassy. Immediate measures were, therefore, taken to organise two field parties, one under Major R. G. Woodthorpe, R.E., to proceed *viâ* Kuram and the Shutargardan, to join the column under General Sir F. Roberts; the other, under Captain Holdich, R.E., to proceed *viâ* Peshawar and Jalalabad, to join the column under General Bright. The formation of these two parties was deemed expedient, so as to secure as much topography as possible along the two lines of advance. Eventually both parties met at Kabul, where they were employed in making the most of every opportunity which was presented by the movements of the forces to add as much as possible to the geography of the surrounding country; in continuation of the preceding surveys, they operated westwards and southwards, up to the Pughman Range and over almost all the country which is drained by the Logar, Shiniz, and other affluents of the Kabul River.

Some additional geography was obtained in Southern Afghanistan, between Kandahar and Girishk, and along the valleys to the west and north-west of Kandahar. A connection with the operations in Northern Afghanistan was also made by the survey of the route from Kandahar to Ghazni, through the Khushk-i-rud, Tarnak and Ghazni Valleys. In Beluchistan a rough reconnaissance was made of a considerable portion of the country north of Sibi, inhabited by the Marri tribes, and detailed surveys were commenced in the plains around Sibi and Dadur.

These operations will now be described in the following order: 1st, Northern Afghanistan; 2nd, Southern Afghanistan; and 3rd, Beluchistan; to be followed by, 4th, a report on the general organisation of survey operations with an army in the field.

I.—The Operations in Northern Afghanistan.

Personnel.

Captain T. H. Holdich, R.E., Officiating Deputy Superintendent, 3rd grade.
Mr. T. E. M. Claudius, Surveyor, 4th grade.
Mr. W. W. McNair, Assistant Surveyor 1st grade.
Two sub-surveyors (The Munshi and Bozdar).

On the re-occupation of Gandamak, in November, 1879, by the advanced brigade of General Bright's division, under Brigadier-General C. Gough, the survey party, under Capt. Holdich, R.E., joined the brigade. Captain C. Strahan, R.E., had previously executed a triangulation in the Jalalabad Valley and beyond as far as Gandamak, and had fixed points on the Karkacha Range to the west, which were of much use in extending the topography into the plains of Kabul. Additional triangulation was required to connect the operations in this quarter with those of Major Woodthorpe in the Kuram Valley and around the Shutargardan Pass, and to complete the general system of triangulation in Northern Afghanistan. This was effected in due course, as opportunities offered on the advance of the troops.

Personnel.

Captain (Brevet Major) R. G. Woodthorpe, R.E., Assistant Superintendent, 2nd grade.
Captain G. W. Martin, Assistant-Superintendent, 3rd grade.
Mr. M. J. Ogle, Surveyor.
Sub-Surveyor Hira Singh.

Major R. G. Woodthorpe's party, which had proceeded *viâ* the Kuram Valley, reached Ali-Kheyl, on the 4th October, a few days after the force under General Sir F. Roberts had advanced on Kabul. Here it was detained until nearly the end of October, when General Hugh Gough arrived at the Shutargardan Pass, with orders to withdraw the garrisons from the posts there and at Ali-Kheyl, and take them on to Kabul. A day's halt at the Shutargardan enabled Major Woodthorpe to ascend a hill in the neighbourhood, from which a good view was obtained, enabling much work to be done, both with the theodolite and plane-table, but for which Major Woodthorpe would not have been able to connect the triangulation of the Kuram

Valley with that of the Logar and Kabul Valleys, which now together form a continuous series from Thal round *viâ* Kabul to Jalalabad.

At first, however, little could be done in the way of triangulation, and it was found necessary to base the topography on a traverse with a subtense theodolite from the Shuturgardan Pass *viâ* Kushi to Kabul, and even this was executed with considerable difficulty, owing to the length of the marches with the troops. Points determined by this traverse were every night plotted on a plane-table, and, with the aid of these, Captain Martin was enabled to make a fairly accurate preliminary reconnaissance of most of the Logar Valley on the scale of 1 inch to 4 miles.

The party arrived at Kabul on the 4th November, 1879, and Captain T. H. Holdich, R.E., as the senior departmental officer, assumed charge of all further survey operations in Northern Afghanistan.

Mr. Ogle, of Major Woodthorpe's party, was detained in the Kuram Valley, and accompanied General Tytler's column into the Zaimukht country, west of Kohat, where he secured topography to the extent of 880 square miles in country which was very little known. On completion of this work he proceeded to Kabul, and took part in the survey under Captain Holdich.

On the occupation of Kabul and partial investment of Sherpur by Mahomed Jan's forces in December, the officers of the survey were temporarily transferred to the Field Engineer Department, and either assisted in the construction of defensive works, under Colonel Perkins, the Chief Engineer, or were placed on the personal staff of the Brigadiers and Generals Commanding. After the defeat of Mahomed Jan, Captain Holdich and Major Woodthorpe accompanied a brigade to the Koh Daman, and succeeded in mapping a portion of the country on the ¼-inch scale, and establishing two trigonometrical stations there.

Captain Holdich then joined General Bright's division in the Lughman Valley. Afterwards he accompanied General Sir F. Roberts on his march through the Logar Valley, taking advantage of this opportunity to make a leisurely re-survey of the valley on the ½-inch scale. Major Woodthorpe at the same time considerably improved and extended the triangulation in this valley, and fixed a number of points on the Altimor, Pughman, Deh-i-Sabz, and Karkatcha Ranges.

In April General Ross proceeded with a division through Maidan towards Ghazni, to meet Sir Donald Stewart, then advancing from Kandahar. Major Woodthorpe accompanied this force, and was able to extend the triangulation and topography towards the head of the Logar River, the sources of which have now been approximately fixed. He also ascended two points on the Pughman Range at elevations of 14,400 and 15,000 feet; but, unfortunately the weather at this time had become hazy, and he was unable to take observations to the distant peaks on the Hindu Kush.

In June and July Captain Martin accompanied General C. Gough's brigade into the Koh-i-Daman and Kohistan, where he mapped 700 square miles on the ½-inch scale, and was successful in obtaining information regarding the courses of some of the rivers issuing from the Hindu Kush, and flowing through the Kabul Valley.

Mr. Claudius completed the topography of the country from Gandamak to Kabul on the ½-inch scale, and under the escort and guidance of a friendly Khan of Tezin, he mapped the important bit of country which borders the route across Lataband and the Haftkotal Passes. This part of his work was executed at considerable personal risk, and he was badly frost-bitten in carrying it through.

Mr. W. W. McNair completed the survey of portions of the Asphan and Hisarak Valleys, west of Gandamak and of the Lughman Valley, both on the 1-inch scale, and subsequently he executed a large amount of excellent topography in the Logar Valley, on the ½-inch scale.

In April two officers of the Royal Engineers, Lieut. the Hon. M. G. Talbot and Lieut. F. B. Longe, were attached to the Survey for duty, and did excellent work both as plane-tablers and in taking a share in the calculations for the general reduction of the observations.

The Native Sub-Surveyors were found particularly useful throughout the campaign from the fact of their being able to move about the country without much personal risk, even in disturbed portions of the country; their services were also largely utilised in pushing forward the military survey of the country around Kabul and Sherpur on the 4-inch scale.*

* Captain Holdich reports as follows of the services of these men :—

"The Munshi carried on the mapping (on the large scale of four inches to the mile) of the Sherpur cantonments, and of the country immediately round it, during the actual progress of the investment, and thus really executed some most useful military work. He continued to work through the city and surrounding districts immediately the siege was raised, and before it would have been possible for any European to have been so employed. From a purely military point of view this part of his work was most important. He also undertook an exploration *viâ* the Kunar River into Kafiristan, travelling as a native doctor. There is every reason to suppose he could have succeeded in reaching Kafiristan (for he was never suspected at any time), but for an unfortunate rise of the Safis and Dehgans, The total area mapped in Northern Afghanistan during the season is roughly estimated by Captain Holdich at 10,300 square miles, to which should be added 880 square miles in the Zaimukht country, making in all 11,180 square miles, of which 64 square miles were done on the 4-inch scale, 1276 on the 1-inch, and the remainder on the $\frac{1}{2}$-inch and $\frac{1}{4}$-inch scales, in about equal proportions.

II.—The Operations in Southern Afghanistan.

Personnel.

Lieut. St. G. C. Gore, R.E., Assistant-Superintendent, 3rd grade.
Sub-Surveyors Atma Sing and Saidulla Khan.

On completing the survey of Pishin, which is mentioned in the last report, (see page 209), Lieutenant Gore, R.E., received instructions from Lieut.-General Sir D. Stewart, K.C.B., to proceed to Kandahar *viâ* the Barghana route, which had not been previously surveyed. Accordingly he made a sketch of the route and the surrounding country, and amalgamated it with the previous surveys on the more direct routes to Kandahar. On arrival at Kandahar he was employed in making surveys of the surrounding country, including an area of 160 square miles in the fertile and well cultivated country along the banks of the Argandab and Dori Rivers to their junction, which he mapped on the 1-inch scale. He also extended the triangulation towards Giriskh.

Subsequently he accompanied an expedition into the Argastan Valley, which proceeded as far as the village of Bodozai, about 8 miles between the point where the river issues from the hills. The Sundarzai villages were also visited, and the Tagak Kotal, through which an excellent road passes into the Tarnak Valley, was explored. This road was afterwards used by the 1st Brigade of the Ghazni column on their march towards Kabul. Lieut. Gore states that—

"Of the three rivers forming the Argastan basin the Kushk-i-Rud is the smallest; its total length is about 50 miles. A fair body of water, however, comes down it, but it is very brackish and nasty

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which took place most unexpectedly. Returning to Kabul, he was next employed in mapping a part of the district adjoining Kabul (stretching through the Chardeh plain to the district of Pughman), which had been entirely closed to European officers, and which it appeared likely would altogether remain a blank. Here he succeeded perfectly, and finished a valuable bit of 1-inch topography, extending to the main crest of the Pughman Range.

"Saidulla was further occupied, for some time previous to the evacuation of Kabul, in completing a portion of topography near the line at Jalalabad, where it was advisable to employ native rather than European agency."

to drink. Of the remaining two the Argastan has probably the larger basin, as a good deal of the drainage, which on old maps was shown as running into the Kadanai, is now known to flow into the Argastan. The Lora River is said to take the overflow drainage of Lake Ab-i-Istada, and when the lake overflows the river water comes down very salt."

From Badozai the expedition turned to the south and marched skirting the main range of hills through the Kadanai plain until it reached Dabrai on the road from Quetta to Kandahar. A good reconnaissance of all this country was made, and was based on trigonometrically fixed points. Subsequently when General Stewart's force advanced from Kandahar on Kabul, *viâ* Ghazni, Lieutenant Gore accompanied it, and was attached to the 1st Brigade, which commenced its march on the 30th March. The route taken led for two days up the Tarnak Valley, thence across the Tagak Pass, on the watershed between the Tarnak and Argastan Rivers into the Khushk-i-Rud Valley, at the head of which it crossed an almost imperceptible watershed, and re-entered the Tarnak Valley, opposite to, but about 10 miles to the east of, Kalat-i-Ghilzai. From this point onwards the route followed the foot of the Surgarh hills, which form the eastern flank of the Tarnak Valley, up to within a short distance of Shahjui, in latitude 32° 31′ where the 1st Brigade joined the main body of the army. The whole force then advanced into the valley of the Ghazni River, and fought the battle of Ahmed-Khel on the 19th April, and reached Ghazni two days afterwards.

Up to Shahjui Lieutenant Gore's work was based on trigonometrically fixed points, but beyond he had to rely on plane-table fixings and traversing until he reached the Wardak Valley above Ghazni, and was able to effect a junction with the survey brought down by Major Woodthorpe from Kabul. While halting at Ghazni Lieutenant Gore made a large-scale sketch of the ground in the vicinity of the city, in which he was assisted by several officers of the force. He accompanied a small force sent to reconnoitre the Altamur Pass, and had hoped to reach the summit of the pass, and obtain a good view of the Zurmut Valley beyond, but this was found impracticable, as the hills were occupied in considerable force by the enemy. On reaching Kabul Lieutenant Gore was permitted by Sir Donald Stewart to return to India, in order to complete his mapping.

Major E. P. Leach, V.C., had proceeded to Europe on sick leave, in consequence of a wound received during the first campaign. On his return he was sent to Kandahar to be available—in communication with Colonel St. John, R.E., the Political Officer—for any survey work which might be wanted. Few opportunities were presented for survey operations, but Major Leach succeeded in reconnoitring a portion of the Argandab Valley, and in extending the previous year's survey of the Khakrez Valley eastwards for some distance. He also fixed a number of the peaks on the watershed between the Argandab and the upper waters of the Tirin Valley, and obtained some valuable information concerning the passes into and across the Hazara country. Unfortunately—

"The whole of this material, together with a series of valuable notes concerning the Hazara tribes and country, was lost during the retreat from Maiwand and during the subsequent evacuation of the Kandahar cantonment."

The survey portion has, however, since been replaced during an exploration made by Lieutenant the Hon. M. G. Talbot, R.E., and Lieutenant F. B. Longe, R.E., and Major Leach has drawn up from recollection and some brief notes which he had saved, a *résumé* of the information which he had collected of the Hazara country and people, and has embodied the results on a sketch map, which, he says—"is so far valuable that it gives an idea of the general lie of a country which is at present a perfect blank, and the relative positions *inter se* of the more important tribal divisions."

At the beginning of June Major Leach sketched a portion of the Maiwand district, which lies at the foot of the Shah Maksúd Range, and is intermediate between the Garmao and Khakrez Valleys, in continuation of the previous survey of the Khakrez Valley. He subsequently accompanied General Burrows's force to Giriskh, and did good service on the staff during the disastrous battle of Maiwand and retreat to Kandahar. He was then appointed Brigade Major of Engineers, and served in that capacity throughout the defence of Kandahar and in the subsequent battle of Kandahar, when the enemy, under Ayub Khan, were defeated by the British troops, under General Sir F. Roberts. For some time after these events further survey operations at a distance from Kandahar were impracticable; meanwhile a survey of the city and its environs was commenced on the scale of 6 inches to the mile.

Lieutenant the Hon. M. G. Talbot, R.E., and Lieutenant Longe, R.E., accompanied General Sir F. Roberts in his memorable march from Kabul to Kandahar; they were present at the battle of Kandahar, and have since been employed in such survey operations as the movements of the troops enabled them to undertake.

III.—The Operations in Beluchistan.

Personnel.

Major R. Beavan, S. C., Assistant Superintendent.
Mr. J. T. U. Coxen, Assistant Surveyor, 1st grade.
Mr. H. Corkery, Assistant Surveyor, 3rd grade.

In September, 1879, as there was no immediate prospect of more survey being undertaken in Southern Afghanistan, Major Beavan was directed to proceed from Kandahar to Quetta to survey the country between and around Quetta and Sibi as opportunities offered. On arrival at Quetta he found that an expedition was about to start under the Political Officer, Captain Showers, to explore the route to Sibi, *viâ* the Hamra Pass. Furnished with the approximate positions of several prominent peaks which had been fixed by previous triangulation, he proceeded *viâ* Astangi through the Tiri defile to Sangan, whence he accompanied Sir R. Sandeman to Sibi *viâ* Harnai, leaving Captain Showers to explore the country to the north for a direct road to Sharigh and Dargi.

While at Harnai he was able to visit the hill of Torgarh, about six miles to the south, from which a good view was obtained of all the country towards Sangan and Nari.

Afterwards he went to Khost in the Dargi Valley, where he met Sir R. Temple, Governor of Bombay, and accompanied him to Tal, from which place he subsequently accompanied military expeditions towards Chotiali and to Baghao and Smalan on the north-east.

Major Beavan had considerable difficulties to contend against, as the disturbed state of the country prevented him from deviating to any distance from the routes followed by the troops; but he succeeded in making a rough reconnaissance on the scale of 1 inch = 4 miles, of about 2,500 square miles between the parallels of 29° 15 and 30° 20′ and the meridians 67° 10′ and 68° 50′ extending from Quetta to Tal-Chotiali, and down to Sibi, which was of much use afterwards to the engineers employed in laying out the new line of railway. He also completed some triangulation near Sibi and Dadur.

The assistant surveyors (Messrs. Coxen and Corkery*) completed a survey of 1,500 square miles around Sibi, Mitri, and Dadur, in detail, on the scale of 1 inch = 2 miles.

Major Beavan proceeded in April to the Head Quarters at Mussuri, with his field maps and original records and observations,

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* Major Beavan reports that "both Messrs. Coxen and Corkery have undergone a great amount of very hard work, and had difficulties and privations to encounter. The work they have turned out has been carefully done, and they have succeeded in dealing with the Pathan and Beluchi inhabitants of the country without raising opposition or provoking complaints, which I consider highly creditable to them."

with a view to completing the calculations and preparing the fair maps. This work done, he returned to Sibi in July, to resume field operations whenever and wherever it might be found practicable to operate in the hill tracts of Beluchistan lying on the northern frontier of the Province of Sind.

IV.—On the General Organisation of Survey Operations with an Army in the Field.

In the General Report for last year, a special report on the experience gained regarding the sufficiency of the general organisation of the survey operations during the campaign in Afghanistan was made, under the instructions from the Secretary of State for India, prescribing that all experience on the work and organisation of the several departments engaged, directly or indirectly, on the conduct of the campaign, should be reported on and recorded for future guidance.

During the present year a committee was assembled at Kabul, under the orders of General Sir Donald Stewart, G.C.B., for the purpose of considering the equipment necessary for a survey party in the field. The committee was composed of Lieut.-Colonel Stewart, of the Guide Corps, as president, and Major Woodthorpe and Captain Holdich, of the Survey Department, as members. Their recommendations were as follows :—

"1. A survey party should consist of one officer (who should be both accustomed to triangulate and to use the plane table) and of two assistants (one of whom should be competent to triangulate) as topographers for each column operating on an independent line in a country where no survey has hitherto been made.

"The native establishment for a party of this size should be as follows :—

For 1 officer	7 followers	inclusive of interpreters and permanent guides.
,, 2 officers	10 ,,	

"The addition of native sub-surveyors must depend entirely on the nature of the country under survey, but when they are employed extra public followers, at the rate of at least one per sub-surveyor, will be necessary.

"2. The instruments for the equipment of such a party will be as follows :—

1 six-inch subtense theodolite, with full vertical circle and tripod stand ;

5 plane-tables, viz., one for the officer in charge and two for each assistant.

"The two for each assistant should be interchangeable on one stand, and should be of different sizes and portability. The Committee are of opinion that the plain deal table, 30″ × 26″, has, on the whole, been found to be of the greatest use on account of its superior size and stability. It can be slung with its stand on a mule or pony without difficulty, and can be used with cavalry. But each assistant should also be provided with a lighter, smaller, and more portable table, which can be conveniently slung on a man's back; a really portable table of this sort has yet to be devised, as also the best kind of stand.

"Each officer or assistant should also be provided with the following minor instruments and books, viz.:—

2 trough needles, 1 sight-rule, 1 telescope or binocular, 1 aneroid barometer, 1 prismatic compass and stand, 3 thermometers for determining the boiling point of water, ordinary air thermometer, 1 Gunter scale, 1 beam compass, 1 small box instruments, 1 Shortrede's log. Tables, 1 Chambers's log. tables, 1 auxiliary tables for facilitating the computations of the Great Trigonometrical Survey.

The officer in charge should carry in addition:—

1 Abney's level, 1 set scales, 1 maximum and minimum thermometer, 1 Nautical Almanac, 1 prismatic subtense instrument, 1 parallel ruler, 1 pantagraph, 1 Manual of Surveying, 2 sets measuring tapes (steel), 1 perambulator, lamps for observing, 1′ 6″-heliotrope, 1 chronometer watch, 1 portable sun-dial, spare compass and drawing pens.

"3.—Stationery.—The ordinary forms in use should be indented for before starting, in quantities suited to the nature of the work likely to be undertaken, but not more than three month's supply either of forms or stationery need ever be carried.

"4. Office tentage and baggage allowance should be on the same scale as that of the senior Quarter-Master General with the division.

"5. In addition to the usual personal baggage scale, the following will be required for the head quarters' camp:—

Office tent	150 lbs.
,, table	20 ,,
Stationery and small instrument	160 ,,
Maps and data	50 ,,

"For public followers 1 sepoy's pal, holding 17 persons, or its equivalent in smaller tents."

These recommendations were made on the following assumptions regarding the nature and extent of the work to be undertaken by the Survey officers:—

"A.—That a large extent of country, embracing several thousand square miles, may be either actually visited or sketched from a distance during the course of a campaign.

"B.—That every surveyor should be equipped to act independently, if necessary.

"C.—That there may be no opportunities of visiting any portion of the ground twice, and therefore that all surveying must be done *pari passu* with the more or less rapid movements of troops along the main lines of communication.

"D.—That maps are to be compiled and traced in the field, so that all the work of the Survey can be put into the hands of the Generals concerned as speedily as possible.

"E.—"That the topographical operations are not to consist merely of surveys of the lines of route, but are to embrace as much as possible of the surrounding country, and must, therefore, be executed on a trigonometrical basis; consequently, that the surveyors must always work together in pairs, one doing the triangulation, the other the topographical sketching; for, when the troops are marching rapidly, it is impossible for any single man to do both, and each is required to supplement the other.

"F.—That the Survey Office with the Army will be the general depôt for all maps of the country which may be published by the Surveyor General's Department, and be supplied for distribution as required.

"G.—That the sanctioned allowance of baggage and equipment for every officer in the field who is employed in transport, commissariat, or any other duties which oblige him to carry his own camp equipage, and make it impossible for him to join a mess, is 400 lbs."

The recommendations were obviously much influenced by the circumstance that the military occupation of Afghanistan was long protracted, so that the whole of the equipment specified by the committee had been found to be necessary. It will be obvious, however, that much valuable work of military survey and reconnaissance may be done by officers who are equipped more lightly, with instruments fewer in number and of a smaller size; and indeed that when a force has to march with great rapidity through an enemy's country, as in General Sir F. Roberts's march from Kabul to Kandabar, it would be absolutely necessary to restrict the equipment of each Survey officer to what might be readily carried about by himself and one or two attendants.

It will be obvious that the nature of the equipment must be materially influenced by the nature of the duty which the officer has to perform, that is to say, by the consideration whether he is expected to make a general geographical survey of as much as can be seen of the country, or a detailed topographical survey of the principal military roads and lines of communication, and the ground in their immediate neighbourhood. Both surveys may be invaluable to the officers commanding the forces, but it is scarcely possible for both to be performed satisfactorily by the same individuals and the same processes of operation. The general geographical survey of the country is not required to give much minute detail, but it must be conducted with some precision, in order that what it does give may be accurate; on the other hand, the topographical sketches and reconnaissances are required to give full details of the configuration of the ground on both sides of the principal military lines of communication, and more particularly to show all the hills by which the roads are commanded; for them, however, fullness of detail is of infinitely greater importance than precision of execution. The geographical survey is mostly of value for rapid strategical movements over a large area of country, while the topographical is mostly of value to aid a general officer in determining the best disposition of his troops in action or wherever liable to be attacked by an enemy. The geographical survey must necessarily be made on a much smaller scale than the military topographical sketches, and it would be of very little use wherever minute detail is required; but, on the other hand, the topographical sketches would by no means suffice of themselves for the construction of a really accurate map of the country.

In the first Afghan War a large amount of route surveying was executed. It was mostly done on the scale of 1 inch = 1 mile, and some of it appears to have been of very good quality; but few, if any, attempts were made to carry on a general geographical survey of the country *pari passu* with the military route surveys. Thus, when the latter came to be combined together, large gaps were found to exist in our knowledge of the country; sufficient data were not even forthcoming for an accurate combination of the work which had been done, the result being that in the maps of Afghanistan, which were executed on the basis of the route surveys, the cities of Kabul and Kandahar are shown respectively as 7 and 15 miles west of their true positions relatively to places in the same parallels of latitude on the British frontier.

It was the chief duty of the officers of the Survey Department who served in the last Afghan war to endeavour to obtain as much information as possible of the country at large, and not merely to operate on the military lines of communication. For this purpose they were directed to make general maps of the country—on scales of $\frac{1}{2}$ an inch or $\frac{1}{4}$ of an inch to the mile, as might be most suitable in each case—by the method of plane-tabling on a trigonometrical basis; also to carry route surveys, on the 1-inch scale, with the most suitable instruments available, over the principal roads traversed by the troops. They were, of course, expected to make themselves generally useful whenever occasions might arise for their employment on other duties; but it was contemplated that whatever work of military reconnaissance and sketching on scales larger than that of 1-inch to the mile might be required, would be done by some of the numerous field engineers and staff officers attached to the army, who were more or less skilled in the performance of such duties. Thus, it has resulted that the bulk of their work is on the $\frac{1}{4}$ and $\frac{1}{2}$-inch scales; their route surveying on the 1-inch scale became generally merged into their smaller scale maps; they surveyed Kandahar and the surrounding country within a radius of ten miles on the 1-inch scale, and Kabul and its environs on the 4-inch scale; but the bulk of the work of military reconnaissance was done chiefly on the 6-inch scale, by field engineers and staff officers who were attached to the several divisions of the army; regimental officers were also largely employed in making field sketches and reports.

The Surveyor-General is of opinion that this separation of the work of precise military survey from that of approximate military reconnaissance, the former being allotted to the professional military surveyor, the latter to the staff officer or field engineer, is a judicious arrangement which deserves official recognition, and should be laid down as a rule for future guidance. It was found to work well on the whole during the late campaign, though it was not formally introduced, but merely came to be adopted in course of time as the most appropriate way of employing the several officers whose services were available for the various kinds of work to be performed. Had the principle been generally adopted from the outset, even better results might have been obtained, and there are many excellent reasons for its adoption in future campaigns in India. The survey of a large extent of country, more particularly during hurried movements of troops, is one which is obviously more likely to be performed satisfactorily by a military officer who has been constantly practising the duties of a professional surveyor than by a field engineer or staff officer who has been as constantly employed on other duties. On the other hand, in the work of military reconnaissance, the professional surveyor may, from want of military training, be often at a disadvantage as compared with the staff officer, and may not succeed as well in obtaining local information on various points affecting the movement of the troops, which is usually of great value to a general officer, and may even be of more importance than the topographical sketches; this work should, therefore, be performed whenever possible by staff or regimental officers, rather than professional surveyors. Such division of labour has the further advantage of employing each officer on that work in the success of which he is most immediately interested.

The recent publication of the report of the Committee appointed by the Secretary of State for War to report on the System of Instruction for Military Sketching and Surveying, in the British Army, affords the Surveyor General an opportunity of offering suggestions on the recommendations of the Committee on two points of importance which may well receive further consideration. First, the "re-introduction of the plane-table in its simplest form" as an instrument of survey; and, secondly, the "substitution of the system of showing hill features by shading in mezzotint, with stump and powdered chalk, or lead from a pencil, for the one now in force of indicating them by horizontal hachures."

The Committee recommend the re-introduction of the plane-table on the following grounds: that it is "the principal instrument used in India for surveying;" that it "can be now made as light as the sketching case, which every man working with a prismatic compass usually carries;" and that it may be employed in countries, such as Southern Africa, "where the prismatic compass was very unreliable, and in some cases almost useless, owing to the powerful local attraction in the ground." Now, it is impossible that plane-tables of the same form and design can be made to subserve the two conditions of portability and independency of the magnetic compass. This may be readily inferred from the following description of the plane-table which is used in the Indian Survey Department.

The plane-table is ordinarily 30 inches long by 24 broad and ¾ths of an inch thick, and is made of the lightest wood procurable, well seasoned and not liable to warp to an extent that will sensibly distort the plane of the table. It is usually supplied with a strong and well braced tripod stand, on which it can be set up and clamped very firmly; folding tripods with tightening screws are also used occasionally and are about two-thirds of the weight, 12 lbs., of the braced tripod. The plane-table is also supplied with an ebony sight-rule, which is usually about 27 inches in length, by 2 inches in breadth, and carries brass sight vanes about 4 inches high at each end, by means of which the rule can be truly directed on any surrounding object. The lower surface of the rule and the upper surface of the table being both truly planed—so that the rule will rest evenly on all parts of the table over which it may be brought—the two together constitute a surveying instrument which may be employed independently of any instrument for measuring angles, such as a theodolite, sextant, or magnetic compass, provided that the table when set up is fairly clamped to its stand, and is not liable to be thrown out of position by the lightness or weakness of its supports. But if the plane-table is to take the place of all other instruments, and be employed in localities where local magnetic attraction renders the prismatic compass useless, it must be true in surface and free from shake: thus, it cannot be made materially lighter than the ordinary Indian plane-table, which weighs about 25 lbs. with stand and sight-rule complete, and cannot well be carried about by less than two persons, and is certainly a very awkward instrument to take about on horseback.

It would appear, therefore, that the officers who have reported to the Committee in commendation of the plane-table on the grounds that "the table itself can be now made as light as the sketching case which every man working with a prismatic compass usually carries; and the legs, which are separate, can be made so as not to be much more inconvenient to carry than a large stick," must have been thinking, not of a plane table forming a complete survey instrument in itself as above described, but of one requiring to be used in combination with a magnetic needle to govern the setting-up of the table, and, therefore, as useless as the prismatic compass would be in localities influenced by local attraction. Still, such an instrument would be very serviceable in furnishing a small table, on which the topographer can work in much greater comfort and ease, and therefore with greater rapidity than on the ordinary sketching block.

The magnetic needle is usually of so great assistance in enabling a plane-table to be speedily adjusted to the true meridian that a long trough needle is invariably supplied to every plane-tabler on the Indian Survey. The table is first brought into position with the aid of the needle, and finally adjusted by the sight-rule on surrounding fixed objects, as the magnetic position cannot be relied on. But firmness and trueness of table, and accuracy of sight-rule, are essentially necessary to obtain good results when the plane-table is employed, as usual, independently of all other angle-measuring instruments, after once it has been brought into position.

On the other hand, a much smaller table than the Indian plane-table, mounted on a folding tripod stand, such as is usually supplied for the support of a prismatic compass, may be used in combination with a small theodolite, with entire satisfaction as regards accuracy of results, though with somewhat more of labour than in the case of the plane-table pure and simple; for the angles must be measured with the theodolite and laid off with a protractor. But the operations would be independent of the magnetic needle, and unaffected by any accidental displacement of the table. Probably the best and most convenient of theodolites to employ for extended operations in which more or less precision is necessary would be Casella's little alt-azimuths, with 3-inch horizontal and vertical circles divided to read minutes, telescopic power $5\frac{1}{2}$, weight in box $4\frac{1}{2}$ lbs., weight of stand $3\frac{1}{2}$ lbs. For ordinary topographical reconnaissance it would suffice to employ a prismatic compass, which might be rested on the table itself; then the extra weight to be carried about, as compared with that of a hand-held prismatic compass and sketching block, would be merely the excess of the weight of the table over that of the block, *plus* the weight of the folding tripod-stand, all which need not be more than 5 lbs.

The question of the propriety of employing the plane-table, pure and simple, is much influenced by the scale on which the survey or reconnaissance is to be made. The instrument is specially valuable for determining the positions of all surrounding points which are visible at two or more fixed stations, or for determining the position of a station at which the table is set up, by interpolation from surrounding points which have already been fixed by triangulation. The plane-table in Northern Afghanistan was at the outset entirely based on points which had been fixed on the summits of the great mountain ranges in previous years, by observations from the frontier stations of the Indian triangulation, and of which the positions are given in Synoptical Volume I. of the results of the operations of the Great Trigonometrical Survey of India. Many of these points were 30 to 60 miles distant from the plane-tabler: thus, as the size of the tables was 30 by 24 inches, a larger scale than $\frac{1}{4}$th of an inch to the mile could not be used without discarding several of the more distant points, which might often be of much service to the plane-tabler in interpolating his position.

The scales recommended by the War Office Committee are 1 to 2 inches to the mile for roads and rivers, and 6 inches for positions and camps. The largest of these scales was adopted in Afghanistan for the Kuram Valley and the road from thence to Kabul, *viâ* the Shutargardan Pass, for the road through the passes between Kabul and Jalalabad, and for the Khaibar Pass. Obviously, where so large a scale is used, the work must necessarily be of the nature of reconnaissance rather than exact survey. When done on a sketching block, a large number of sheets of paper must be used, and this is very troublesome at the time and afterwards in joining the sheets together. For reconnaissance on a large scale, regular plane-tabling is not suited, as a sufficiency of well-marked points for the plane-tabler to work on would probably not fall within the limits of the paper. But when working with a small table and a prismatic compass, in the manner indicated (see page 237), paper mounted on cloth in sheets extending considerably beyond the limits of the table, may be used with advantage, with the aid of a few drawing brads to pin down the sheet on the board at the part which is wanted. This method was practised during the last three years of the Trans-Indus Survey of 1849-54, and was found most convenient; the paper, mounted on brown holland, was obtained in rolls a yard wide, from which any desired length, usually $1\frac{1}{2}$ yards, might be cut; the table was only 1 foot square, and was mounted on a stand of a prismatic compass; the angles were measured with a 5-inch theodolite, the smallest available at the time, and were plotted with a protractor and marquoise scales; the scale of the survey was 1 inch to the mile; the paper was pinned down to the board with brads when in use, and rolled up and kept in a wax cloth case when not in use. The whole of the instruments might be carried about by two persons, whether on foot or horseback, without difficulty. For ordinary military reconnaissance a roll of paper mounted on cloth, 12 to 18 inches wide and 24 to 30 inches long, would probably suffice, and a wax cloth cover would be ample protection for it while being carried about; the corresponding instrumental equipment would be a light table, 10 to 12 inches square, mounted on a folding tripod stand; a prismatic compass, a protractor, and a scale with folding sights which might be used on occasion as a sight-rule.

As regards the substitution of shading in mezzotint for the present system of horizontal hachures, in order to show hill features, there can be no question that maps so produced could be drawn with greater rapidity, and would, as a rule, be clearer and better understood. When only a single copy of a sketch or map is wanted nothing better can be desired. But if several copies are wanted as speedily as possible, as frequently happens, then the map should be drawn with a view to adapting it for the only process which is at present known for obtaining speedy reproduction and multiplication, *viz.*, photographic transfer to stone or zinc. This process enables pen and ink drawing, however elaborate and complicated, to be reproduced and multiplied satisfactorily and with great rapidity; but it cannot reproduce mezzotint. Thus an original drawing in mezzotint must always be re-drawn by hand, on transfer paper or stone, before it can be multiplied, and this is usually a slow and laborious process, requiring much more time than direct reproduction by photography; consequently, all maps and sketches which are required to be speedily multiplied should be drawn in pen and ink. As regards reproduction it is immaterial whether the hachuring of the hill features is drawn vertically or horizontally; but for clearness and general legibility vertical hachures are usually preferable in small-scale maps, and horizontal in large-scale ones.

The speedy reproduction and multiplication by this Department of the maps and sketches which were received from Afghanistan, directly or through the Quarter-Master General's, the Foreign and other offices, constitutes a feature of much importance as regards the connection of the Survey Department with the general business of the campaign. Up to the end of 1880 over 400 maps and sketches, in sections of various sizes, ranging from "double elephant" down to "foolscap," obtained from all quarters, were reproduced by photozincography; upwards of 50,000 prints were taken, giving an average of about 125 copies for each subject: the average time which elapsed between the receipt of an original map or sketch in the photozincographic office and the issue of the requisite number of copies from that to the despatch office, was five days for each subject, including Sundays and holidays, and the time spent in examining the proofs and correcting the zinc plates; ordinarily, when the original was clearly drawn, so that the plates did not require correction, 200 copies could be supplied without much difficulty on the third day after its receipt in the photographic office; and in not a few cases copies were despatched to the Generals and Staff Officers in Afghanistan by the third day.

In some instances the prints were rough and coarse, but this was because the originals were in the same condition. Photozincography cannot do more than produce a facsimile of any subject; it cannot improve on, and indeed is liable to produce something slightly less good than the original. But a map, however rough and coarse, may, if supplied *instanter*, be often of far more value than an elaborately finished map supplied some time afterwards. Thus the general principle was followed, of furnishing the Government Offices, the Army Head Quarters, and the Officers commanding the troops in Afghanistan, with facsimiles of all maps and sketches precisely as received, so that the persons most interested might be placed as speedily as possible in possession of all the latest information available. New maps were compiled in the Surveyor General's Offices as soon as possible after any new information was received; and new editions of previous maps were published from time to time as rapidly as was practicable. But the labour of re-drawing and compiling was great; and a long period was consequently liable to elapse between the publication of the facsimiles of the primary materials, and the publication of the maps into which these materials were incorporated. Thus, the speedy publication of the originals was a desideratum of great importance, and the Survey Department may claim credit for the manner in which that want has been supplied.

It may be here stated that most of the maps supplied for the use of the officers in Afghanistan were printed on calico instead of paper. Prints on calico are nearly as sharp and clear as on the best paper; the cloth is lighter, more readily folded, much more convenient to carry about, and far less liable to be torn and injured, than any of the various kinds of paper on which maps are usually printed. On the other hand, they are not so well suited for the insertion of corrections and additional matter. Thus, a few prints on paper were also furnished to supplement the prints on cloth.

PAPER XIII.

FORTIFIED CAMPS.

A reply to Major Parnell, R.E.,

By Captain G. S. Clarke, R.E.

In Paper X., Vol. IV. of the *R.E. Professional Papers, (Occasional Papers)* Major Parnell unburies an old and now nearly forgotton controversy, the history of which is as follows:—

In Vol. IX. of the *R.E. Professional Papers*, (second series) Major (now Major-General Sir W.) Jervois, gave some details of works proposed and in progress for the defence of "Naval Ports, Arsenals, and Dockyards." This drew forth a reply (No. XVII., Vol. XII.) from the late Colonel Cunliffe Owen, whose paper was read at an occasional Corps Meeting and discussed at some length. In Paper XVIII., Vol. XII., Captain (now Colonel) Wilson replied to Colonel Owen, and finally, in Paper XIV., Vol. XIII., the latter had his 'last word.' This was read at Chatham on the 6th November, 1863, and a discussion followed, from the abstract of which it may be gathered that the general opinion of the Officers present was against Colonel Owen's views.

At the time in question the supersession of smooth bores by rifled artillery had become certain, and, in consequence, the minds of Military Engineers were naturally much occupied with the consideration of the changes which the defence would have to adopt. In a paper read on the 7th March, 1863, Colonel (now Major-General) Gallwey, R.E., discussed at some length "The influence of rifled ordnance on the attack and defence of fortresses;" while the siege of Düppel by the Prussians in 1864, and some of the sieges of the American War, in which, for the first time, the attack employed rifled guns, provided some practical data bearing on the new considerations which presented themselves. The period was not in any sense the beginning of a revolution in the science of fortification, but it certainly marks a new point of departure in the evolution of defence, which has led by slow and carefully considered steps to the Metz of to-day.

The principle of detached forts found acceptance, however, when rifled guns were still in their infancy, and cannot be said to have had its origin in the development of the range of artillery alone. It is probable that the great growth of the suburbs of large towns, and the great increase of the perimeters of the areas to be defended would have led independently to the adoption of the fort system in preference to that of a continuous *enceinte*.

Fortification, like all branches of military science, cannot be independent of conditions non-military. While towns were comparatively small, a well traced continuous *enceinte* encircling them at a moderate distance afforded efficient defence. The spread of buildings would, however, not only fill up the whole of encircled area, but soon produce large suburbs close outside the circle of defence, while, on the continent at all events, the existence of fortification would naturally attract and stimulate building enterprise. To prevent the uprising of new towns round the old *enceintes*, would either require the exercise of a despotic power, which modern political tendencies might render difficult, and in some countries impossible, or the purchase of large tracts of ground at a vast outlay—an outlay, which, as the tracts would be unavailable for building purposes, could only pay a relatively insignificant interest.

The alternative of tracing new and extended lines of defence would, therefore, inevitably present itself; and into this extension all kinds of new topographical conditions would enter. It is fully admitted that under certain circumstances Colonel Owen's and Major Parnell's favourite continuous lines are best, but such conditions are, it is strongly maintained, exceptional. If all commercial, military, and strategic centres were situated on level plains, or on isolated conical hills, fortification would reduce itself to its simplest terms. Estimates for systems of defence, based on a mere knowledge of the length of perimeter to be defended, the nature of the soil, and the current cost of labour, would be possible and reliable. The great difficulty of fortification, however, is the demand it makes on the genius of adaption. It can hardly be too strongly asserted that fortification is not an exact science, and that the greatest engineer is he who can best adapt fixed principles to very varying conditions. General Hamley in his "Operations of War" called attention to the extreme simplification—amounting to falsification—of military problems, which can be attained by ignoring topographical conditions. Strategy and tactics become so simple when expressed and explained in a diagrammatic form, but the application of the apparently simple diagram to the actual field of battle is a vastly different matter. And this same species of apparent simplicity veiling real complication, runs through Major Parnell's paper, and those of Colonel Owen, culminating in a diagram given by the latter to illustrate the different systems of fortifications which he discussed.

Faced by the necessity of widely extending their lines of defence, both on account of the growth of the areas which it was desirable to defend, and also the probability of a great increase in the range and power of artillery, military engineers appear with one accord to have adopted the principle of detached forts for the outer line of defence, employing them either as an advanced line covering an old continuous *enceinte*; or to supplement a new continuous line; or, as in the London Defence project, to which Major Parnell alludes, to form the sole permanent defence.

Major Parnell admits that "continental nations ought to know their own interests," and that the construction of detached forts as a system of defence has received new impetus since the Franco-German war. In spite of the admitted concensus of opinion on the point, however, Major Parnell, basing his conclusions upon those of Colonel Owen, expressed some 18 years ago, does not hesitate to condemn the detached fort system and to propose a new one which appears to be of a very reactionary nature. He starts with a group of definitions which seem open to exception. By the first he would restrict the term 'fortress' to works strengthened by 'continuous permanent fortifications,' applying that of 'fortified camp' to places or positions strengthened by "detached forts or works." This definition seems neither adequate nor satisfactory. Are Paris and Portsmouth, therefore, fortresses or entrenched camps? Both have *enceintes*, but their main defences are detached forts. Supposing two equal fortified areas, one surrounded by a continuous line, the other by a ring of forts, the strategic advantages of position and the commercial, political, or military importance of each being equal, why is one a fortress and the other an entrenched camp? In a later definition Major Parnell states that the works of a fortress should usually be of a 'permanent' and those of an entrenched camp of a 'field nature;' which, though very intelligible as an opinion, does not serve to elucidate the first definition. Is the point of difference between the two things a question of trace, or of permanence, or of size? Metz and Paris are spoken of as fortresses with subsidiary entrenched camps at the beginning of the paper. Ought their detached forts to have been of a field nature, and would they really have been "of the most advantageous form when improvised and thrown up in time of war by the General commanding the army?" Is Metz a "prepared battle field," or a "prepared siege field," or both, and are its detached forts in any sense "subsidiary" to its *enceinte*? Several other considerations are suggested by these definitions which would seem to need partial revision even from their proposer's point of view. The last 'definition' states "the least efficient application of it (an entrenched camp) is to the land defence of a naval arsenal or dockyard." Does the entrenched camp here mean a system of detached permanent forts, or of field redoubts, the latter being the best form in Major Parnell's view?

One reason given for this want of suitability of forts to the defence of a naval arsenal or dockyard, is because "it is particularly an object to prevent the capture of such places as well as their bombardment." It is usually the object of fortification to avert capture, and though the position of the ring of encircling forts would, in such a case, be determined with a view to prevent an enemy from establishing batteries within bombarding distance—to insist upon a regular siege in fact—the tacit assumption here involved that a place is more liable to capture if defended by detached forts than by a continuous line, cannot be allowed to pass unnoticed. This assumption practically begs the whole question at issue in the paper under consideration.

Quitting definitions, Major Parnell proceeds to discuss the value of continuous lines, basing his remarks on Colonel Owen's papers. The latter are mainly a gallant defence of an old and familiar system by one who did not readily accept changes, and felt difficulty in reconciling himself to new views. Moreover they were written many years ago and their author, had he been spared to us, would doubtless have found reason to modify considerably the opinions he then held. These two papers will not, however, it is thought, be considered to "form a model of sound reasoning," and the title of the second "Fortification *versus* Forts," by which it is baldly implied that forts are not fortification, gives some clue to the way in which the subject is approached.

Colonel Owen's main contentions were as follows:—

1. A continuous line is as cheap as a detached line.
2. It can be defended by a smaller number of men.

3. Imperfectly trained troops are not suited to the defence of detached works.
4. The defence of a continuous line is simple and easily understood.
5. Continuous lines are sanctioned by long experience.
6. An enemy can pass between detached works.

Leaving the two first for the present, the third would seem to be open to question, especially since the defence of Gorny Dubnik. Imperfectly trained troops are not "suited" for any operation, but in many respects, a self contained work where they would be easily supervised and kept in hand, and where panic would be less difficult to restrain, would seem to be the best place for them. The fourth is of a highly doubtful character, and Colonel Owen's arguments that confusion of authority would exist in a system of detached forts, and that the constitution of no army would permit the selection of proper officers to command them, do not strike one as particularly forcible. The fifth has apparently little or no value: smooth bores had the sanction of long experience, bows and arrows longer still. The sixth will hardly carry conviction. That a force would ever attempt to pass between well placed, well traced, and well armed forts, is hardly conceivable. The forts occupy, or ought to occupy, all the commanding points; they defend the roads; the intervening ground is known and prepared; to effect any tangible result such a force would have to take artillery and the impedimenta of an army, and granting that by night, or in a fog, it could penetrate the interval between a pair of forts, it would find itself in front of another fort, cut off from its base and exposed in rear and both flanks. It is assumed of course that a single ring of forts would frequently be inadequate, unless the position were one in which the passive defence was intended to be supplemented in time of need by a large field force.

In the same volume of the Corps papers as that in which Sir W. Jervois' original paper appeared, Capt. (now Sir H.) Tyler discussed the future of permanent fortifications, and his paper, which is in many respects a marked contrast to that of Colonel Owen, is remarkable for its breadth of foresight. Captain Tyler states "long continuous lines are more expensive to construct, more difficult to defend, require larger bodies of troops to garrison them, are liable to be equally weak at all points, become useless when they are forced at any one point, and are devoid of that principle of defence between one fort and another which can now be so effectively employed."

How does Major Parnell meet these grave objections? In the first place he adopts Colonel Owen's figures to show that the difference of cost is only about 4 per cent. in favour of detached forts. But these figures cannot, it is maintained, be admitted to be worth much unless the topographical conditions are ideal. The cost of a detached fort could, for a given garrison, known soil and price of labour, be fairly estimated, but it is very difficult indeed to arrive at a satisfactory estimate of the cost of a continuous *enceinte*. The trace of the latter, "following the contour of the ground" as Major Parnell intimates, would bear no simple relation to the perimeter of the defended area. Given that the perimeter is 25 miles, as in the hypothetical case discussed by Captain Lewis, R.E. (Vol. I., *Occ. Papers*, 1877), and assuming an interval of about 5,000 yards, nine forts would be required for its defence. Assuming the garrison and armament, a fair rough estimate of the total cost of the defence project might be arrived at. But it is strongly maintained that no satisfactory estimate of the cost of a continuous *enceinte* could be framed without a complete knowledge of the topographical features of the ground to be fortified. It is worth notice that, as might be expected, Captain Wilson, in the discussion which followed the reading of Colonel Owen's second paper, stated that his estimates led to a "very different" conclusion. It is submitted, therefore, that the figures Major Parnell adopts are of very doubtful value, and while it is not proposed for the reasons stated to attempt to frame a new estimate of comparative cost, it may be briefly noticed that the cost of a system of defence will depend, roughly speaking, on the length of the ditch to be excavated, the garrison to be provided with cover being supposed the same, and that it would seem that the economic advantage must lie with detached forts disposed at the intervals which modern fire allows.

Major Parnell holds that the continuous line would require a less garrison to defend it, and alludes to Captain Lewis's paper (Vol. I., 1877). For nine forts at 5,000 yards interval, the latter arrives at a field force of about 28,000 men, independent of the garrisons of the forts, this number being made up of 14,850 for picquets and guards, and 13,500 mobile field force: Major Parnell, under similar conditions, estimates the field force at 169,200. This difference is appalling, and with such an estimate as the latter in view, it is small wonder that Major Parnell condemns the forts.

Captain Lewis's estimate is based on very simple and rational assumptions. He provides—(1st) a chain of picquets of 25 men each at 300 yards interval, with double sentries detached to the front, supported by four main guards of 300 men each for *the whole of the intervals* between the forts; (2nd) a force sufficient to defend 3,000 yards in each of two intervals. This force he takes at 3 men per yard, a very fair estimate. Of course Captain Lewis is considering the question of minima garrisons, which after all is the real question of importance. Major Parnell's vastly greater estimate is arrived at in a different way. He allots 20 yards of fort to each gun, and 15 guns to each fort, thus obtaining 300 yards of ground "covered" by each fort, and 2,700 yards for the whole ring of forts. The remaining length of perimeter (42,000 yards) he considers unfortified, and provides a force of 3 men per yard for its defence, with a reserve of one-third, thus reaching the great total of 169,200 men. The assumption that the amount of ground covered by the forts is a simple multiple of the number of guns which "can fire simultaneously over the front" does not appear particularly satisfactory. The actual area of ground covered by the forts would be mainly a topographical question and since, in the case of forts, mere frontal fire is not the only thing to be considered this assumption seems unscientific.

Captain Lewis's assumption that, out of an interval of 5,000 yards, 2,000 yards are defended by the forts seems to be a very fair one. If the forts do not defend this distance, they are either badly armed, badly traced, or wrongly placed.

Major Parnell goes on to state that guns should be provided at the rate of at least 24 per 1,800 yards, which would give 600 guns for the hypothetical 45,000 yards—a very heavy armament. Now putting 600 guns round this perimeter, and allowing 10 yards (not 20 yards as before) per gun, Major Parnell reduces the field force to 156,000 men. His principle is thus to base the strength of the field force on what he terms the unfortified ground, and to arrive at the extent of the latter by deducting from the whole perimeter of defence the product of an assumed number of guns into 20 (or 10 ?) yards. Now reduce this unfortified ground, or adopt a continuous *enceinte*, and "when the fortified camp becomes a fortress no field force at all is required." Apparently, therefore, by adopting a continuous trace with 24 guns per 1,800 yards we may knock 156,000 men off the strength of the garrison at one stroke. This is fortification with a vengeance. The £6,500 per mile advantage conceded to the fort system may well be abandoned by the most rigid economist in face of such a saving of men. Yet this is Major Parnell's meaning, for he states elsewhere "If there is an advantage which such (*i.e.* continuous) lines afford, it is that they enable a continuous line of troops to be dispensed with, for they actually substitute themselves for troops." It is impossible, however, to believe that the difference between the two systems is so enormous as this, and Major Parnell, in the figures above quoted, seems to prove too much.

A few words will serve to set forth the opposite view. The range of artillery and the extent of the town, dockyard, arsenal, or camp to be protected, fix, roughly speaking, the perimeter of the line along which fortification must be employed. In most sites—Portsmouth, Plymouth, Paris, and Metz, are cases in point—topographical conditions will greatly modify this line. There will be marked points, which more or less command the surrounding country and the converging roads. These points will be the natural positions for the defenders' artillery. It will be now necessary to protect the artillery thus massed at the commanding points, and to house and cover the gunners and an adequate infantry force. Thus arises the detached fort system, which may be said to be based on the principle of being strong at decisive points, as opposed to that of being relatively less strong along the whole line of defence. The analogy of the defensive tactics of the field of battle is perfect: no one having a line to defend would, unless on a dead level plain destitute of all topographical features, dispose his force in an uniformly dense line; he would base his distribution on the features presented by the ground.

Suppose, for example, that a continuous *enceinte* were traced round Plymouth, as Major Parnell advocates, and it is hardly conceivable but that some portions of it could actually be looked into, others easily enfiladed, some even taken in reverse by long range fire. In parts of such a line both artillery and infantry fire would be cramped, and unable to exercise their full force except at very short range. In other parts the ground in front would afford scope for more fire than the continuous line could afford, since one part of the latter could seldom give support to another.

Major Parnell attaches great value to the inviolability of the continuous line, and above all to the defence afforded by an escarp, but the defensive power of the latter is surely dependent rather on efficient flanking than on mere height. One of the points which most strike one in studying the systems of the old masters is the fact that they trusted very little to a mere continuous escarp, such as Major Parnell advocates, and sought strength in elaboration of trace and in retrenchments.

It is but fair, however, to remark that it is not quite clear from Major Parnell's paper whether he is putting the case of detached forts *versus* such elaborate continuous lines as that formed by the German (unhappily termed *polygonal*) trace, or of detached forts *versus* a mere single line of continuous obstacle such as he proposes at the close of the paper. Either the system above alluded to, or the bastioned trace (unfortunately termed *modern* French), with their ravelins, *reduits*, and defensible glacis, form, it is clear, something very different from the elementary line Major Parnell proposes. It is important that this point should be rendered clear, for Major Parnell may perhaps claim economy for his system, while, if continuous lines in the old sense, with all their adjuncts, are meant, the economy would certainly rest with the forts. It is most unlikely that continuous lines in the old sense, will be constructed in these days on an extended perimeter, the difficulties of adapting them to most sites, would alone form an almost insuperable objection.

Major Parnell bases his argument for economy of garrison on the assumption that a continuous line need not be manned throughout. The term "manned" is somewhat vague, and while it may be conceded that it would not be necesary to line every banquette with men, it is nevertheless strongly held that it would be necessary to provide a very considerable force for watching a long line not only at the period of investment, but even after the direction of the systematic attack had declared itself.

Again, while it may be granted that escalading would have small chance of success against an active garrison, holding a modern fort, it is maintained that Major Parnell's long line of simple escarp and rampart, in which fortification has been substituted for troops, would offer very considerable chances to an enterprising enemy.

Another serious objection to the continuous line remains to be noticed. It almost destroys the best weapon of an energetic defending force, the power of delivering effective sorties. Behind the screen of detached forts, an army can be brought together, and can move forward at the chosen moment in approximate order of battle. From a continuous line it can emerge only in narrow columns of march, and at a comparatively few points. Whatever might be the offensive power of the defending troops, it would be almost wholly lost if the latter had once permitted themselves to be driven within a line of continuous fortification.

Major Parnell's proposed system is termed a "combination of continuous escarps and detached batteries," and consists of a continuous line with rampart, ditch, and glacis, (the latter not, however, generally necessary) supplemented by "detached permanent batteries placed at the most advantageous sites in rear." There is thus a single line of obstruction, defended by a single line of musketry, and the rear line of detached batteries, the latter forming, according to the author "the real ramparts of the fortress." There is to be no sunken defence for the ditch, and flanking defence for the foot of the continuous escarp is to be obtained by indenting the latter, or by "simply following the contour of the ground." Permanent retrenchments are to be provided if money permits, but whether they are to consist of another line of detached batteries, or another continuous escarp is not stated. The "batteries are to be without ditches or inner enclosures," and would "in many cases consist simply of lengths of casemated ramparts built of concrete, and covered in part by masks of earth."

These are the main features of the system proposed to replace that now so widely adopted. The plan contains, however, one feature which appears to be not altogether consistent with the views of the writer concurrently stated. Thus, although much space is devoted to shew the uselessness of detached forts, and the superiority of the continuous line—this in fact seems the main object of the paper—we are told that the continuous line in the system of the future is not the real rampart at all, but that the "real ramparts are broken up into detachments in the form of batteries." It is believed, however, that the main impression derived from this paper, and those of Colonel Owen, will be that the breaking up of the rampart into detachments is the great error of modern fortification.

It is not easy to see what advantage is gained by this system over that which Major Parnell condemns. The weak continuous line wandering along the contours of the hills, would almost certainly be liable to enfilade at some portions of its extent. Unless constantly well manned, it would be liable to surprise by parties, who could by night descend into the badly flanked ditch, breach or escalade the escarp, or possibly even bridge the ditch. Once fairly penetrated, the line would be lost, and the defenders would have to trust to their detached batteries, and their vaguely specified retrenchments.

There is no reason to suppose that the batteries would possess any greater individual resisting power than well constructed redoubts, and if, as seems to be intimated, they are intended for frontal fire, it would be more easy to pass between them than their condemned rivals. It is willingly granted that the design of some not very antiquated forts is open to criticism, but this does not by any means tell against the detached fort system, and it is maintained that Major Parnell's line of detached batteries would be vastly inferior in resisting power to a line of well built detached works, and that the continuous escarp is inferior in conception to the non-continuous field lines which could be thrown up between the latter when the direction of the real attack had become apparent. Moreover the continuous permanent line would, it is believed, be a positive disadvantage to the defenders by cramping their power of making sorties.

Major Parnell draws upon the experiences of the Franco-German war to support his view, but his deductions are surely open to question. "The fortified camp at Paris does not appear to have delayed in any material degree the starvation-caused surrender that overtook the place. Without any forts in front the *enciente* would have held out equally long." But it can hardly be maintained that the Paris forts exerted no influence on the blockade, that it would have been no advantage to the Germans to have been able to draw their lines closer, no disadvantage to the French to have been cramped within a far less area. And with regard to Metz it does not seem sufficient to say—"the fortified camp formed by the Metz forts proved to be the ruin of the disheartened army that sheltered there, and of the fortress in their rear." . . . "It may almost be stated that if Metz had been without forts France might have been saved." May it not also be stated that if Metz had had six months' provisions, the blockade of Paris (momentarily endangered on the 10th November) could not have been maintained, and the issue of the war might have been different? Both are perhaps narrow and incomplete views of the question, but the second is not more incomplete than the first. It is admitted that the creation of large defended areas may tend to the enfeeblement of strategy by tempting a weak commander to cling to the security they promise; but this tendency would exist whether the areas were defended by detached works, or continuous lines. Moreover, if the latter are really the stronger, the temptation to run to earth would be enhanced by their adoption.

Many other opinions expressed in Major Parnell's paper tempt remark. Thus he replies to the obvious criticism that a continuous line fails if pierced at any one point, by the assertion that "*not* to be pierced at any one point, is the very end of all permanent fortifications." In a sense, of course this is true; invulnerability is the ideal striven after by the Engineers of permanent works, but a glance at the elaborate traces of the old continuous lines suffices to shew that prolonged defence, after partial penetration, was the main object of their designers. And it is hardly correct to say that "it seems quite a novelty in fortification to rely on fire as an obstacle at all." Passive obstructions are always secondary to living force, and fortification may almost be defined as the art of giving to one side an advantage in using their weapons over the other. In the days of modern arms, it is not too much to say that fire is the chief and most important of all obstructions.

Again, Major Parnell, in his anxiety to condemn forts, seems to do injustice to Captain Wagner's 'Principles of Fortification.' The latter advocates the frequent shifting of siege guns, and their employment between the intervals of permanent works, in fact, the employment of field and provisional works to supplement permanent defences. This Major Parnell characterises too hastily as a "feeble arrangement." The great majority of fortified places will, it is certain, never have to undergo attack, and the most scientific fortification is surely that which provides adequate primary defence, and is capable of rapid development when the necessity arises. This is one of the greatest advantages of the detached fort system, and, in these latter days, a general return to the principles which actuated the builders of the great wall of China does not seem practicable.

G. S. C.

PAPER XIV.

PRIZE ESSAY FOR 1877.

By Lieut.-Colonel R. Harrison, R.E.

'THE DUTIES OF THE ROYAL ENGINEERS IN TIME OF WAR, AND THE BEST ORGANISATION FOR ENABLING THEM TO CARRY OUT THOSE DUTIES.'

Introduction.

In discussions on the tactics and organisation of Infantry, Cavalry, and Artillery, it has been said, with truth, that the changes effected by modern arms of precision have been so great, as to render superfluous a study of wars in which such arms were not used; and to warrant an almost exclusive attention, by the military student, to the details of the *last great war*, in which breechloader first met breechloader, and rifled guns and 'Gatlings' were opposed one to the other.

But, in the case of the duties of the Engineer, the circumstances are not quite similar. In all ages, and in all wars, rivers have had to be crossed, roads to be made, cities to be defended or taken. Earth and wood have ever been, and are still, the principal materials used by the Field Engineer in his trade. The *thickness* of the material, indeed, has been increased or lessened according to the weapons used against it; and *the form* has varied according to the skill or caprice of the constructor. New conditions have, no doubt, from time to time arisen in consequence of the introduction of gunpowder, and, in later days, of the railway and the telegraph. But the great change that has taken place in the duties of the Engineer in time of war may be said to have been caused by the *need of rapidity in execution*. This need was appreciated by those whose foresight created the almost perfect army that we now see in Germany. And the example set by Prussia has been followed by most European nations. It has been understood that unless the Engineer, with his tools and materials, was on the required spot at the required moment, he might almost as well cease to exist. And it has been found an economy of labour in military, as it has long been recognised to be in civil engineering, to separate to a certain extent the various duties that have to be performed, and to have a special corps for each. Thus we find a Pontoon Train, whose special duty it is to bridge rivers; a Telegraph Train, to connect the various parts of an army, and keep the General in communication with his men; a Railway Corps to repair and work military railways; Mounted Pioneers to accompany Cavalry, and destroy railway lines and bridges; Field Engineers for general use in the field; and Garrison Engineers, whose special duty is the siege and defence of fortresses and entrenched positions.

In any consideration of the duties of the Royal Engineers in time of war, it is natural that we should turn to the last great war in which England conducted any *field operations* against a European enemy—that in the Peninsula. But we must remember that in those campaigns—lasting as they did for several years—against an enemy far from his base, and with his means of communication long and difficult, time was afforded to our country to rectify mistakes. An organisation for nearly every branch of the army was extemporised on the actual theatre of operations; to die out again when the need was over, and be forgotten during the long peace that ensued.

The arrangements made for Engineer duties were perhaps 'rougher,' of a more 'hand to mouth' description than those of any other arm.

A force of 49 Military Artificers was all that was allotted to Sir J. Moore's force, in his campaign, and subsequent retreat to Corunna.

Only 28 were with the army that landed subsequently in Portugal, and fought the battle of Talavera.

The lines of Torres Vedras were constructed under the officers of the Royal Engineers, by 18 Military Artificers, superintending working parties of soldiers and peasants.

And 27 men were all that could be spared for the first and second sieges of Badajos.

These Artificers, too, knew little or nothing of the duties of a Military Engineer: they had never seen a sap or a battery; and they had to be drilled on the spot in the formation of field works, and in making fascines and gabions. But they were clever workmen; able to superintend the construction of a bridge or a jetty; and they soon acquired a rough knowledge of the requirements of war.

In the summer of 1811 the total force of Artificers in Portugal was 177. These men were for the most part scattered about in the various forts. But a detachment was sent with the moving army; and this detachment was broken up into small bodies of five or six men, one of which accompanied each Division.

Matters improved as the war went on. More Artificers arrived from England. Their organisation was changed. They were trained to a certain extent before they set sail. And in the Corps of Royal Sappers and Miners, that emerged from the war in 1813, one is apt to forget or overlook the few Military Artificers on whom the brunt of the work fell. But the fact is that, in the Peninsular War, or at all events throughout all the earlier part of it, the officer of Engineers was more of a staff than a regimental officer; that a great proportion of the engineering work was carried out, apart from the Engineers, by an organisation extemporised on the spot; and that the Military Artificers, and subsequently the Corps of Sappers and Miners (which was created during war for *siege purposes*), only assisted, to a limited extent, in the various works of engineering that were undertaken in the field.

Hence it was not unnatural for officers of Cavalry and Infantry, who in after times were in positions of authority, to depreciate the work of the Sapper, to think that it would be time enough on the outbreak of a war to organise any force of Engineers that might be required for the field, and only to sanction the existence of a Corps of Sappers and Miners on the understanding that, independently of garrison work, they were doing what no other arm of the service is supposed to do, viz., repaying to the state by their civil labour what it cost the country to raise and maintain them.

The conflict with Russia in 1853—the next great European war in which England engaged—did little or nothing to alter this feeling.

The Corps certainly showed to advantage in the Crimea, and, by its gallantry and determination, gained a name that will not soon be forgotten. But it was only at siege works that it was employed. Organisation to a certain extent was possible on the spot. No field operations were undertaken. And hence the need of any further organisation than existed was not apparent.

Prussia, on the other hand, taught by her misfortunes in the Napoleonic wars, regarded military necessities with another eye. For many years she had carefully studied and experimented on the best organisation of all arms for purposes of war. And the astounding and rapid successes that she gained over the Austrians in 1866, and the French in 1870–71, awoke even England to the fact that in these days there is no time to organise armies after war is declared; and that *that* nation will win who, *cœteris paribus*, has the best proportion of all arms in its ranks, and has taken the most pains to organise and equip them before the war breaks out.

Shall we then analyse the duties of the German Engineers in the last great war? Such a course would, no doubt, be most valuable and instructive.

Shall we take the German organisation as the model for our own? To do so to the exclusion of other experience would be to ignore the peculiarities of our Empire, and to assume that Great Britain would, for the future, only engage in a European conflict, and such an assumption would be an extremely presumptuous one.

England is a great commercial nation; she owes her prosperity and her strength to the sea which surrounds her shores, to the colonies which she has founded, and to the trade which she has developed.

In connection with these sources of national prosperity—to maintain her naval superiority—to tranquillise her colonies—to protect her trade—she has, not unfrequently, to engage in wars of more or less magnitude with Asiatics, and with savage tribes. Such wars are quite independent of any European conflict into which she may be drawn.

In a consideration of the subject before us, we have a problem to solve different to that of any other nation on the face of the globe. We have to consider what are the duties of the Engineers of a nation which, in the last twenty years, has engaged in a great European war with one of the most powerful military kingdoms in the world; has, unaided, put down the mutiny of a large army of well disciplined and organised Asiatic troops; has carried on a successful war on the easternmost shores of Asia, and, from the sea as a base, marched her troops some 150 miles inland through an unknown and fabulous country, until she planted her victorious standard on the walls of the ancient capital of China; has conquered savage tribes in New Zealand, and on the frontiers of India; has made the power of her name felt in East Africa, by wrenching from the hands of the King of Abyssinia the European captives whom he had immured in a stronghold situated in the midst of that almost inaccessible country and guarded by his, till then, invincible army; and, finally, has conquered the savage king who was a terror to all Western Africa, carrying the war inland through a country so deadly in climate that beasts of burden could not live there.

Divisions of Subject.

In order to consider the question thoroughly, I propose,

1st. To describe briefly the past organisation of the Royal Engineers, and some of the war duties that they have already performed;

2nd. To glance at the work done by the Engineers in the last great war between France and Germany;

3rd. To detail the organisation of the Engineers of one or two foreign nations;

4th. To state what is our present organisation; and

5th. To discuss what alterations time and experience seem to suggest as necessary in the organisation of the Royal Engineers, to enable them best to fulfil their war duties, and at the same time to maintain as far as possible their general 'usefulness' in time of peace.

I.—Past Organisation and History.

In considering the duties that have hitherto been carried out by the Royal Engineers, under their various names, in time of war, it is obviously unnecessary to take into account the deeds of individual officers who, either alone, or assisted by one or two overseers, accompanied an English expedition, and organised an Engineer equivalent out of the materials that came to hand. Such cases have been frequent in English history. That they have been successful reflects credit on individuals, and bespeaks a certain amount of national energy and aptitude for war. But it indicates, at the same time, that there was a want of readiness and organisation on the enemy's side; and that thus the needful time was afforded in which to create a useful force out of the raw material. Independently, however, of these considerations, the examples above mentioned have little bearing on our present purpose, which is to consider the duties and organisation of the Royal Engineers for war—the duties, that is, of *an organised body*, comprising officers, men, horses, and equipment, and forming an integral and important part of the army with which it is associated.

The first English corps of Military Artificers was formed in 1772, for work on the fortifications at Gibraltar. It was commanded by officers of Royal Engineers. In 1779 Spain declared war against England, and blockaded Gibraltar. The garrison, under General

Elliot, consisted of 5,382 men, including a Company of Artificers, 104 strong, and 8 officers of Engineers. During the siege the Artificer force was augmented to 234; and throughout the protracted defence it took no small part in the fighting.

In 1788 a Corps of Military Artificers was raised for service in England. It consisted of 6 Companies, each Company being organised as detailed in Appendix (A). This Corps, like the Gibraltar one, was commanded by officers of Royal Engineers. In 1789 it was distributed as follows:—a Company at each of the following places, viz. Woolwich, Chatham, Portsmouth, Gosport, Plymouth, Guernsey, and Jersey.

The first account that we have of Military Artificers being employed in *the field* was when a Company, 86 strong, was sent, in 1793, to join the army in the Low Countries under the Duke of York. These men took with them intrenching and tradesmen's tools, and were employed in field operations as well as at the siege of Valenciennes and other 'affairs' throughout the war.

A detachment from the Gibraltar Company was, about this time, sent to render assistance at the defence of Toulon.

The usual employment of the Artificers at sieges was as overseers of Infantry and other working parties. But some of the men occasionally worked with their own hands at difficult and dangerous points, such as the head of a sap or the cheek of an embrasure.

In 1793 three Companies were raised for special service abroad; *i.e.* in Flanders and the West Indies. At the end of this year the total strength of the Corps at home and abroad was 588.

The West Indian Company was employed during the various conflicts in those islands in 1794, in the construction of batteries and magazines, and the various works incidental to the attack and defence of fortified posts, as well as in the repair of barracks.

At the completion of the war in Flanders in 1795, the Company which had been raised for service in that country was disbanded.

Detachments of Artificers were, in the same year, specially detailed to repair and add to the defences of the Thames, Portsmouth, and the coast of Sussex.

In 1797 the Soldier-Artificer Corps at Gibraltar was incorporated with the Royal Military Artificers. This raised the total strength to 759 men.

A few Artificers, selected with a view to the duties that it was thought probable they would have to perform, and generally from among the stationary Companies, were sent with each of the expeditions that England fitted out at this period. These detachments appear to have been of considerable use, but the numbers furnished were always insufficient for the purpose.

It was in the year 1799 that the Duke of York, irritated at the reluctance of the Ordnance Authorities to furnish enough Military Artificers for an expedition fitting out for Holland, determined to establish a Corps competent to discharge the duties usually devolving upon the Royal Engineers. And hence arose the Royal Staff Corps. At the commencement of 1801 (according to Captain Connolly) the Corps of Artificers was distributed in Companies and detachments as follows, viz.:—Woolwich, Chatham, Portsmouth, and Gosport, Plymouth, Jersey, Guernsey, Dover, Gibraltar, Minorca, Nova Scotia, the West Indies, Egypt, and Jaffa.

In the Egyptian expedition the Artificers were employed in tracing and making batteries, and keeping them effective during the fight; in constructing a line of defensive earthworks; and in throwing a bridge of boats across the Nile.

The threat of a French invasion in 1804 having created a panic in England, sums of money were freely voted to increase and supplement our coast fortifications. Works of a temporary, as well as a permanent, nature were constructed at every vulnerable point, and the corps of Artificers found full employment. The Military Artificers were assisted in these undertakings by working parties of Militia, and by detachments from the Royal Waggon Train and Royal Staff Corps.

In 1806 three Companies of Maltese Artificers were formed, for duty in Malta and the Mediterranean. These Companies were recruited from among the Maltese and Sicilians, but were officered by the Royal Engineers.

In prospect of a long war, and in order to carry out the extensive works of fortification in progress at Dover and Nova Scotia, a warrant was issued this same year, sanctioning a reorganisation of the Corps for general service, and an augmentation of two Companies. The total of all ranks was increased from 100 to 126 per Company. (For detail of company *see* Appendix B.) The total strength of the Corps was now close on 1,800, officers, non-commissioned officers, and men.

But it may be noted here that, notwithstanding all efforts to improve their condition, and notwithstanding the continual state of war (which is usually so great a spur to discipline and zeal), the companies in no way came up to the standard that their promoters had marked out for them. The principal causes of this want of efficiency were the *nominal* appointment of officers to Companies, and the constant changes that took place among the officers who actually had the command.

This led to the appointment of men to the posts of non-commissioned officers, simply because they were good tradesmen, and quite irrespective of any other qualification. There was little or no distinction between the ranks. In fact, every military idea was sacrificed for a supposed regard to 'the works;' and the consequence was that both suffered.

When England took part in the war already raging in Portugal and Spain, in the year 1808, she could only afford to send at first a weak detachment of Military Artificers (and those by no means the best she possessed) to work under the Engineer officers, and represent the Engineer force in that country. As I have already stated, the main part of the Field Engineers' duties had to be undertaken by other organisations, such as the Staff Corps, Guides, and Waggon Corps. But the construction of field works, and the management of sieges were so essentially Engineer duties that they could not well be entrusted to any one else, and the Engineer officers had to make the most of their few assistants in carrying out these works. The difficulty, moreover, of conducting sieges with a few almost untrained Artificers, and the tremendous loss that such a system entailed on the British Infantry, caused attention to be paid in England to the representation of Sir R. Fletcher and Lord Wellington; and an establishment was formed (in 1812) for instructing the Corps of Artificers in military field works. At the same time many and salutary reforms were introduced into their organisation. In order, too, to bring their name more fully into accord with the duties for which they were specially required in the Peninsula—that is to say the conduct and management of sieges—they were in the autumn of the same year styled 'Royal Sappers and Miners.'

From this time, throughout the rest of the war, being organised in Companies of a reduced strength (*see* Appendix C), they were employed under their own officers as occasion required, not only at sieges, but to assist in the construction of pontoon and other bridges, to make field-works, and to carry on the multifarious duties required of workmen in a campaign.

As many as five sub-lieutenants and 305 non-commissioned officers and men were engaged in the siege of San Sebastian, in 1813, under the officers of Royal Engineers; and the instruction that a large proportion of them had received at the new Field Work School at Chatham, under Colonel Pasley, proved most valuable in this difficult and dangerous undertaking.

In the subsequent passage of the Pyrenees, and advance into France across several large rivers, Lord Wellington derived much assistance from the reorganised Corps.

It is worthy of note that, at the end of the Peninsular War, the force of Sappers and Miners in the English 'Army of Spain' was, more nearly than it had ever been, in accord with the strength thought necessary for the Engineer arm in other armies.

When Napoleon re-appeared in France from Elba, in 1815, and all Europe concentrated their forces to attack him, seven companies of the Corps—the best instructed that could be found—were hurried off to Ostend, and distributed among the frontier posts and fortresses in the Netherlands. Here they were employed constructing field-works, or improving the existing fortifications. The Sappers were not engaged at Waterloo. The reason of this was, doubtless, because they were not 'mobile.' They had left England as *Siege*, and not as *Field* companies. They were thus not prepared for works in the field; and in the rapid concentration of the army there was *no time to change their organisation*. But immediately after the battle, *i.e.*, on June 20, the experience of the Peninsula seems to have been called to mind; for steps were taken to organise a field establishment of Royal Engineers. Thus a Company of Sappers and Miners was attached to each Division; and this Company was completely furnished with drivers and horses, and equipped with waggons carrying artificers' tools, engineer stores, and intrenching tools for 500 men.

A Pontoon Train also was organised, consisting of 80 pontoons, and store waggons, &c., drawn by 800 horses. To this train five Companies of Sappers were attached. And the rest of the *personnel* was made up of hired drivers and Flemish seamen.

It may be well to notice that, owing no doubt to the hasty nature of the Engineer preparations, no ladders were available to escalade the walls of Peronne—the only place offering a resistance to the British advance. Still, the organisation, on the whole, was a success. A pontoon train was *a necessity*. For, without one, months might have been wasted by the allied armies on their road to Paris.

As soon as the war was over reduction became the order of the day; and the Royal Sappers and Miners suffered perhaps more than any other branch of the army. Considerable reductions were made in 1816, and again in 1817; and by a warrant of 1819 the peace establishment of the Corps was further reduced to 12 Companies, numbering a total of only 752 non-commissioned officers and men.

From this time we find that the Corps devoted itself to civil pursuits. Year by year the experience gained during the Napoleonic wars, particularly that in the Peninsula, seems to have become more and more forgotten. And, though the establishment for instruction was maintained at Chatham, there is no doubt that the Corps owed its subsequent augmentation, perhaps even its very existence, to the fact that it was found economical to employ it in various *civil* works in England and the Colonies.

The system returned of sending detachments to accompany war expeditions. These detachments sometimes took with them tools and materials, according to their supposed requirements, which were collected by the energy of the officers appointed to their command. Sometimes they took nothing, trusting to the resources of the country to which they were proceeding. In no case did they start with equipment and transport sufficient to enable them to take the field on landing. In all cases the Engineer force had to be organised on the way, or even in the actual presence of the enemy. The detachments sent to take part in the various wars against the Kaffirs are good examples of those above described.

The first augmentation of the Corps was caused by the formation of three companies, in 1825, to conduct the Trigonometrical Survey in Ireland. The success of the survey led to further augmentation in 1839. And some diving operations, undertaken about the same time, especially the removal of the wreck of the *Royal George*, which had sunk at Spithead, brought the Corps into notice.

In 1841, a Company was raised to carry on the civil works at Bermuda.

In 1846, at the suggestion of Sir J. Burgoyne, when a large increase was being made to the Infantry and Artillery, authority was given to add eight Companies to the Sappers and Miners.

The survey in Ireland being completed, the Corps undertook the larger work of the Trigonometrical Survey in England; and an increase of one Company was the result.

In 1851, the employment of the Corps at the great International Exhibition brought them still more before the public eye.

At the Chobham Camp, in 1853, some men of the Corps were employed in the various 'fatigue' duties incidental to camp life; and a Pontoon Train was extemporised, the stores being brought from Chatham, and the carriages horsed by the Royal Artillery.

The Russian war, that broke out in 1854, found the Sappers and Miners, like the rest of the English army, little prepared for any hostile movement. A Company of Sappers was sent, with Marines and French Infantry, to the Baltic, in August of that year. Tools and materials had been placed on board the ships; and five days being available on landing to collect the tools and make the required preparations, the Company assisted in the bombardment and subsequent surrender of Bomarsund. To meet the expected needs of the war, the Corps was suddenly augmented by the addition of twenty-one non-commissioned officers and men to each Company.

Several Companies were sent to the East, with stores of working and intrenching tools. These Companies were landed at Gallipoli and Scutari, and subsequently at Varna, and were employed on various duties, such as erecting piers, preparing hospitals, making horse-boxes, &c., and also in superintending the execution of field works, and the repair of roads. One Company was detailed to form a Pontoon Train. But when, at the request of Omar Pasha, it was determined to throw a bridge over the Danube, the party that constructed it was formed of officers of Royal Artillery and Royal Navy, besides Engineers, assisted by a detachment of Sappers, French pontooners, and sailors from the fleet. Men and tools were carried on horseback, and it took six days to get to their destination, and twenty-two more before the work was accomplished. The bridge was made partly of trestles, and partly of boats, collected on the spot.

Six Companies of Sappers, carrying tools, accompanied the army on its landing in the Crimea. One was attached to each Division, and one to Head Quarters. At the Alma the Sappers were not employed, nor on the subsequent flank march.

On arrival at Balaklava they were set to work to make roads and sink wells, and to erect a pier; and from that date they were employed at the work for which their organisation fitted them better than any other—viz. the various operations of a siege.

As I have before stated, the way in which the Corps behaved at the siege of Sebastopol, the evidently admirable manner in which they had been instructed at Chatham, and the gallantry they showed in circumstances of extreme privation and danger, gained for them, not only in the army, but throughout England, a military renown as great as the civil one that they had already acquired during the long peace. This renown tended, however, to produce a sense of satisfaction with their existing state, and to make the military authorities forget more than ever the lessons of the Peninsula, and the need of a special organisation for field operations.

After the Crimean war, the Royal Sappers and Miners became the Royal Engineers: an arrangement by which officers and men formed one Corps. Their organisation was nearly what it is at the present time. (*See* Appendix D.)

When the Indian mutinies broke out in 1857, a company of Royal Engineers was detached from the China expedition, and three others were subsequently sent from England to take part in the war. But an Engineer organisation already existed in that country, and stores and transport were plentiful. Hence the Companies of Royal Engineers were only an accessory. There was time, too (especially after the first few months of the war), to elaborate a force for each enterprise and each moving column; so that we can learn no lessons for our present purpose from the circumstances that attended the operations in these Indian wars.

At Canton and the Peiho Forts, in China, the fighting took place within an easy distance from the ships; and the existing system of Siege Companies, aided by local carriers and naval assistance, was found sufficient for the requirements. But when, the Peiho Forts being taken, an advance on Pekin became necessary, some fresh organisation had to be extemporised—in fact a Field Company had to be made out of a Siege one; and it was only the delay of a few days that took place in the advance, and the facility that existed in obtaining country carts and mules, tools, and other necessary materials, that enabled the officer in charge to produce a small Engineer force fit to take the field with a moving army.

The same difficulties were experienced in other expeditions, such as the New Zealand War, and the occupation of Canada at the time of 'the Trent affair.'

In the Abyssinian expedition the resources of India were called forth; and a force of Engineers, suited to the difficulties which were anticipated, was organised at Bombay before the army sailed. This force was supplemented, but (as was the case in the Mutiny war) only assisted by a Company of Royal Engineers sent from England.

Lastly, when it was determined to send a British force to Western Africa to curb the power of the Ashantee king, only three officers and six corporals were sent with the leading party. 'General Grant, when operating against Vicksburg, was opposed by nearly the same physical obstacles which lay between Cape Coast and Coomassie. Tracks for roads, unbridged rivers to cross, swamps to pass through, forests to clear. But, in every Battalion under his command, so large was the contingent of Western Pioneers and back woodsmen, that he never failed to find the practical skill necessary for the rough engineering of the war.' Just the opposite was the case in the African campaign. Perhaps if a force of Royal Engineers, properly equipped, had been the pioneers of the army, instead of nearly the rear guard, the chances of a disaster to Sir G. Wolseley's command would not have been so great, nor his movements so necessarily hurried at the last. In *this*, as in former expeditions, the Engineer force had to be organised on the spot.

Thus, by a cursory review of the past, we have seen that in every war in which England has hitherto taken a part, she has been, at the first, without an Engineer force suited for the occasion. Under these circumstances—although, as already stated, we require to study our own history in order to learn the nation's peculiar requirements—yet it is evident that it will not be wise to place too much reliance on *our* experience *alone*. If we do not study as well that gained by others in modern wars, we may bitterly repent not having done so in some future campaign. The Germans have proved that the Engineer work in the field is one that cannot be left to any chance collection of artisans, nor even to a Corps Reserve of Sappers; and *one of the main changes* in organisation carried out *since* the war of 1870-71 has been to re-arrange the Engineer element, and make each Division carry within itself a sufficiently effective proportion of what they now call the *fourth arm* of the service.

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II.—Engineer Work in War of 1870-71.

We will now proceed to glance at the work done by the Engineers in the last great war between France and Germany.

In the 'Tactical Retrospect' of the campaign of 1866 we find it stated that 'the services of the German Engineers were so little appreciated in that war, that it was not considered worth while to request their co-operation; so that, however willing, they could not take their part in the works. But is it not also a fault in the Engineer himself when the tactician and the soldier is subordinated to the mere architect and constructor? An Engineer who employs all his time in fortifications exchanges voluntarily his position of a soldier for that of an artisan. An Engineer who is a good soldier and an indifferent architect will always be serviceable, even though his constructions may in a measure fail in an artistic point of view. An indifferent construction at the right place is better than an artistic work at the wrong one. The great importance of the Commanding Engineer in an army can only be appreciated when we see him at the side of the General Commanding in Chief, superintending the whole strategic and tactical position, and seizing the opportunity when his own branch of the service can advantageously and actively operate in the battle. The actual carrying out of the work may always be left to subordinates: details easily confuse.

'The next campaign will show us this fourth arm acting in rivalry with the others in the battle.'

Peace manœuvres, which were the means used by the Prussians, in time of peace, to teach their soldiers the lessons of war, do not show sufficiently the use of Engineers. For constructive purposes however, this branch of the service is always prominent; and hence the tendency to sink the Engineer in the builder. But, taught by the lessons learned in the war of 1866, and not too proud to profit by them, the Germans made a right use of their Engineers in 1870. And who can tell how much this fact contributed to the general success of the campaign?

The German organisation for the field was to send Field Pioneer Companies, completely equipped and horsed, in the van of each detached body of troops. Attached to one of the Field Pioneer Companies of each Army Corps was a light bridge train, so that no small unexpected stream should stop the onward progress of the troops. Attached to another Company came the intrenching column, to insure a sufficiency of tools being at hand when required. Distributed where most convenient were the complete pontoon columns, which were ordered to the front to cross any *known* river. In rear of the advancing army came the Garrison Pioneer Companies, which were available for work on the communications, and to conduct sieges, or to assist at protracted investments. There were also Field Telegraph, Field Railway, Torpedo, Balloon, and Photographic detachments, for use as their several titles indicate.

To detail a tithe of the work that the Engineers undertook would cause me to transgress considerably the suggested limits of this essay. Suffice it to say that, by their bridging operations, the Germans enabled their Second Army to march round the retreating French, and prevent the army of Bazaine from leaving Metz for the West; and, by their skilfully planned field-works, they, in a few days, completed a line of investment round that army, which defied all its efforts to break through, and eventually led to its capitulation.

As Pioneers they were no less efficient. Their regulations say that the staff officer with the advanced guard is responsible for the practicability of the roads; and that a party of Pioneers must be always attached to the van of the advanced guard, under an officer who directs the necessary repairs. The distribution of this party is so arranged that at least half always follow on when the other half stop to work.

By this system the German armies were able to execute wonderful marches. Take one as an example. The 12th Corps, when ordered from Metz to march as part of the 4th Army, traversed a distance of 50 miles, as the crow flies, in the first four days, marching chiefly by *bye-roads*, effecting a passage of the Meuse, and traversing a district where every stream runs from south to north, exactly crossing their line of movement.

On the other hand the Engineers of the French army had not profited by the experience of recent wars; nor did the French generals see any need for change in the use that they made of the Engineer arm. It has been said by a clever French writer, speaking of the Engineers of his country, that the 'transfer of officers from the men to the various duties of the staff prevents the development of specialities, and ends in producing a body of hybrid officers who know nothing thoroughly, who have time to become neither accomplished soldiers, skilful Engineers, nor able architects, and whom the very knowledge of their own impotence isolates both from soldiers and Engineers, and who follow but slowly, and even with regret, alterations of the military art, and the progress of industrial discovery. There are very few officers of Engineers who can devote themselves to the study of fortification. The greatest number, scattered up and down in barrack stations, have time and intelligence absorbed in the details of an uninteresting duty. Thus, when war breaks out, these officers, taken from civil duties, and having lived all their lives apart from the military, would have neither the bodily nor the theoretical preparation, nor that knowledge of soldiers which the requirements of active service in the field demands.'

If this be no exaggeration they were far worse than the Prussians were even before 1866—and what strides in progress the latter had made since then! No wonder that there was so much contrast between the work done by the Engineers of Germany and those of France in the war of 1870. Let us take one or two examples, in order to see the result of the two lines of conduct.

At the battle of Mars la Tour the French were more or less surprised by the German advance. Acting on this surprise, two Companies of German Pioneers, who, according to the new plan, were in the vanguard of the advancing column, were pushed with their 6 waggons of tools into the village of Vionville. This village they proceeded at once to fortify; and the consequence was that it was held throughout the day, although to right and left the German line was driven back.

At the battle of Gravelotte, when St. Privat was taken, and the exhausted German Infantry were unable to advance, some Sappers of a Pioneer Company were pushed through the village, and made a shelter trench and epaulments against the still unbroken French Left.

On the other side there were 18 hours available to loophole

Gravelotte, and form intrenchments; yet nothing was done. The whole of the Engineer Parks were in rear of the French position. Th Corps Frossard, on the left, managed to get at some tools, and strengthened its position; and was able to oppose successfully all th German attempts to drive it back. The Centre Corps did more or les of the same work, and were not beaten. But the Corps on the righ (that of Canrobert) had no Engineers with it. Consequently little or nothing was done to strengthen the position at the villages of St Privat and Roncourt, and the post of St. Marie-aux-Chênes; and *her* it was that the French eventually suffered a defeat.

A close study of the campaigns in France in 1870-71 shows us, I think, the important part that field works can be made to play in modern warfare. It show us, too, how necessary it is to have each unit of the technical troops as 'mobile,' and as carefully equipped as possible. And it suggests the advisability of having a body of Engineers capable of accompanying the Cavalry in the raids of that arm against the enemy's communications.

III.—Organisation of Foreign Engineers.

Let us now examine the organisation of the Engineer force of one or two foreign nations.

In Germany the organisation of the Engineers is as follows:—

All general questions as to the defence of the kingdom devolve on a Royal Commission. The officers of Engineers are employed either on *the Staff* or with *the Pioneers*. Those on the Staff have charge of the construction and repair of fortresses. The duties of the Corps do not include barracks except in certain cases. The head of the Engineers is an Inspector-General, under whom are a certain number of Inspectors. Each Inspection comprises so many fortresses and Pioneer battalions. The Engineer Committee consists of a General Officer as president, two Colonels, two Field-Officers, six Captains, and three Lieutenants. Besides the employment in fortresses, and with the Pioneers, there are various duties, such as professorships at military schools, telegraphs, and torpedoes in which the Engineers are engaged. But they are not employed, as a rule, on any purely civil works. In time of war, the staff of the various Inspections is reduced, and this frees sufficient officers for the altered condition of circumstances. The Pioneers are formed into Battalions in time of peace for convenience of instruction and discipline; but, on the order to mobilise, each Battalion sends to the active army three Field Companies, each of which is a complete unit and capable of acting by itself under all circumstances. It also forms three Garrison or Fortress Companies, whose first duty is the defence or siege of fortified places. A Pioneer Company comprises 5 officers, 202 non-commissioned officers and men, 11 train soldiers, 3 waggons, and 17 horses. To each Army Corps there is assigned also on mobilisation two light or Divisional Bridge Trains, and one Corps Bridge Train, two Intrenching Tool Columns, and a Field Telegraph Division. The Pioneers actually employed by Germany in the war of 1870–71 are detailed in the Appendix (E).

Almost all the nations of Europe either have already formed, or are in process of forming, an Engineer organisation for the field similar to that of Germany. The general principle of all is the same.

The Austrians, moreover, have established a system of mounted Engineers; and it is thought that such a body, if well organised and instructed, may prove extremely useful in future wars. Before 1866 they had a certain number of troopers instructed and equipped as Pioneers. And this system was further extended after that war. Their object is to make Cavalry complete in all arms, and consequently independent. Its action in raids on an enemy's flanks and rear can thus be made more effective, and the preservation of a long line of communications rendered more difficult than ever. The Austrian system is to select a certain number of troopers of good character, and who have obtained a first-class certificate in riding, and to train them to Sappers' duties. Each Cavalry Regiment of six Squadrons has a section of 40 men so trained, who are called the Regimental Pioneers. Each Squadron has, in addition, five men called the Squadron Pioneers. The latter are used chiefly for works in camp, such as field ovens, roads, latrines, &c.; but the former are available to make earthworks and bridges, and to destroy railways and telegraphs. The principle is to make them *good soldiers first*, and then to furnish them with a few practical ideas for use in the field.

The Americans reduce their army in time of peace to the smallest possible dimensions; and their Engineers are reduced with it. They trust to their distance from any great military nation, and to their vast internal resources, to enable them to organise an army when required. All the officers who have passed through the military school at West Point have the preliminary education of an Engineer. And the extensive civil works, in which the country is always engaged, form a ready field for the enlistment of Sappers already half trained to their work. So that the organisation of an Engineer force is not a more difficult undertaking than that of any other arm. The American Engineers are charged with planning, constructing, and repairing all fortifications and other defensive works; and also with planning and constructing such civil works of the government as may be assigned to them. In time of war they prepare plans for the attack and defence of military works; they lay out and construct field defences, redoubts, intrenchments, roads, and military bridges, &c.; they form a part of the vanguard to remove obstructions; and, in retreat, they form a part of the rear-guard to erect obstacles, destroy roads, bridges, &c., so as to retard an enemy's pursuit.

The duties of the French Engineers are as follows: In peace—besides detached staff and other employments, the inspection of the frontiers, the inspection of the Engineer forces, the conduct of the repairs and enlargements of all the fortresses, batteries, and places of defence, and also of the military buildings; and the maintenance of all frontier water defences, canals, &c. And in war—the attack and defence of strong places, and reconnaissance of the same; the construction of field works on the march and during operations; that of roads and bridges; and the building of works of fortification in conquered territory. The French Permanent Engineer Committee, or Committee on Fortifications, consists of all the Generals on the active list, and a certain number of Brigadier-Generals made by the War Minister. Its duties are to report on all matters of military engineering submitted by the War Minister, and also on inventions; to suggest annually what objects are of importance and what should be done; to make projects for defence, and for all Government works and buildings; to inspect and muster all officers and men of the Corps; to recommend to the Engineer Department what should be the distribution of the Corps, and what changes should be made from time to time.

IV.—Present Organisation of Royal Engineers.

We have already seen, by tracing out their history, how the men of the Corps of Royal Engineers were first raised, how they have been from time to time employed, and the circumstances that led to their existing numbers and organisation.

In detailing the present duties and organisation of the Corps it will be necessary, not only to consider the men and their immediate officers, but the whole body that makes up the Corps of Engineers of the British army.

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We have then, as nominal head of the Corps, the Commander-in-Chief of the Army. Under him is the Inspector-General of Fortifications and Director of Works. This officer's duties are laid down in the Queen's Regulations (*see* Appendix K). He is responsible for the efficiency and management of the Corps, as well as for the direction of the whole of the works connected with the fortifications, barracks, and other military buildings in the United Kingdom and the Colonies. To assist him in the command of the men, there are three staff officers, and a few clerks, in the department of the Commander-in-Chief. In the execution of his other duties he has a department to himself, and is directly responsible to the Secretary of State for War.

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He is assisted in it by two Deputy-Directors, three Assistant-Directors, a number of attached officers, and a regular staff of surveyors, clerks, and draughtsmen. The Executive work of the department is carried out under senior officers, styled Commanding Royal Engineers, who are stationed at central points in the military districts and Colonies, or at fortreses which form independent commands. The duties of Commanding Royal Engineers are detailed in the Queen's Regulations (*see* Appendix K). Some of these duties are evidently those that would be required to be carried out in a time of war only. But, apart from these, the Commanding Royal Engineer (like the Inspector-General of Fortifications) has a double responsibility, viz., a military supervision over all the officers and men of the Corps who may happen to be stationed in his district, for which he is answerable to the Commander-in-Chief as head of the army; and the duties connected with the Department of Works, for which he is responsible, through the Inspector-General of Fortifications, to the Secretary of State for War.

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Under the Commanding Royal Engineer the bulk of the officers and men of the Corps, and all the civil staff of the Department, are employed; distributed as from time to time may be found most convenient.

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The Corps of Royal Engineers comprises four lists of officers, kept separate for purposes of promotion. These are the Imperial list, the Bengal list, the Madras list, and the Bombay list. The total number is as follows:

Generals	34
Colonels	42
Lieut.-Colonels	98
Majors	152
Captains	183
Lieutenants	374
Total	883

In order the better to discuss their employment we will divide these officers into six groups as follows:

1. Those in civil employ, or unemployed.
2. Those in staff situations.
3. Those in the Department of Public Works of India.
4. Those in the Royal Engineer Department, in Great Britain or the Colonies.
5. Those under instruction.
6. Those who are attached to the men of the Corps.

(1) The civil situations which Engineer officers fill are various, comprising employment under the Board of Trade, and the Home, Colonial, and Indian offices. A royal warrant regulating such employment was promulgated in January 1872. Its provisions were, that officers *lent* to a civil department were to continue on the establishment of the Corps; such officers to receive military pay, and be available for military duty. But that if a *recall* from the civil duty on which an officer was employed would be inconvenient to the civil department, he was to be enrolled on a *Reserve List*, and his place filled up in the Corps. Under these circumstances he would receive no pay from army votes. He would still, however, be available for military service in any *case of emergency*. After 10 years on the Temporary Reserve List he must return to military work, or be placed on the *Permanent Reserve List*.

(2) The staff situations which officers of Engineers hold are for the most part those peculiar to the Corps, and instructorships at military colleges. For an officer of Engineers to hold what is known as an 'Army Staff' appointment is very rare, if we except those Commanding Royal Engineers of districts who are colonels on the staff, but whose title is only nominal.

(3) The Department of Public Works employs the majority of the officers in India, in the same manner as the Royal Engineer Department does those at home and in the Colonies. The two Departments differ, however, considerably in their constitution, and in the way in which they utilise their officers. When the Department of Public Works was first started in India, it was a purely military one, its duties being connected with the forcible occupation of the country. These duties consisted chiefly in the construction of forts and magazines at detached stations, and of an occasional barrack. At first it was officered only by Engineers, and military rank was sufficient for authority and supervision. But when the number of Engineers became insufficient for the growing needs of the department, and officers of Infantry were employed by it, it became necessary to establish the system of depart-

mental rank. This system really makes the Department a civil one. In the year 1854 the management of the Department was taken from the Military Board, and entrusted to a separate Department of the Supreme Government. Thus its civil nature became a recognised fact. With the new *régime* irrigation works were taken up; and a better style of barrack and civil building was erected. The policy of the government, which was to improve the country generally by means of public works, led naturally to the enlargement and increased importance of the department. Many civilians were added to it, and it became less a military institution than ever. The system of the Department—as carried on in upper India, where most of the stations for British troops are to be found—is as follows: Each large military station, with perhaps small surrounding ones added, forms a Division under an Executive Engineer, with assistants as needed. Five or six Divisions form a Circle, presided over by a Superintending Engineer. Superintending Engineers correspond direct with an Inspector-General; but the Executive Engineer is responsible for the accounts, and orders and superintends all works in his district. For any particularly important work a special Division, independent of the usual Executive Engineer, is formed. These special Divisions are grouped together under a Superintending Engineer who corresponds, as before, with the Inspector-General, through a Chief Engineer for special military works. Irrigation works and railways are separate charges, but form branches of the Department.

While on the subject of the Department of Public Works, I may mention that the duties of the Royal Engineers in India may be divided under the following heads: (1) the Department of Public Works above described, which is sub-divided into its three branches of (*a*) Irrigation; (*b*) Buildings and Roads; (*c*) and Railways; (2) the Survey; (3) the Telegraphs; and (4) the Military Duties connected with the Sappers and Miners.

(4) The Royal Engineer Department is nominally a military one. Its business is the conduct of all *the works* in Great Britain and the Colonies. That is to say, it has the charge of the construction and repair of fortifications and barracks, the custody of War Department lands, and the undertaking of all the other duties incidental to the care and maintenance of Government property and buildings. Engineer officers only are employed in it; and they take precedence in it according to the rank they hold in the Corps. To assist the officers there are, in the first place, civil surveyors, to check measurements and make any large estimates; and, secondly, military foremen of works, clerks, and draughtsmen, who make small estimates and work.

ing drawings, and conduct correspondence. The military foremen, &c., are selected from the men of the Corps, then subjected to a severe examination, and finally put through a careful course in the Construction School at Chatham. The designs of fortifications and barracks are, as a rule, made at the central office of the Department in London. The business of the local Engineer is to fit the type supplied to him to the selected site, and then to superintend the construction of the building. The Department is not allowed to *initiate* work. It simply carries out what others suggest.

(5) The officers under instruction are those young officers who have obtained temporary commissions in the Royal Engineers, and who are going through the Chatham course, which is intended to fit them for the various duties they may have to perform. The construction course, of about nine months' duration, is the one intended to qualify them for employment in the Royal Engineer Department. It may be stated here that the original Chatham course, which comprises instruction in field fortification, surveying, telegraphy, and construction, is considered sufficient for an Engineer officer for his life. No further test of his proficiency is required of him in his after service, except the slight military examination required of all officers before promotion.

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(6) Lastly, there are the officers who are attached to the men of the Corps.

The Corps musters at the present time a Pontoon Troop (120 yards of bridge), a Telegraph Troop (30 miles of wire), an Equipment Troop (tools for three Companies and a Field Park), and 43 Companies. The detail of a Service Company, as approved for war, is given in Appendix (D). This detail varies considerably according to circumstances. The war strength of the troops is given in Appendix (F, G, and H). No special arrangements exist for raising the Troops and Companies to their authorised war strength from their existing peace establishment—(for peace establishment, *see* Appendix J). The Companies are employed as follows: 25 in various works connected with the fortifications or barracks under the Royal Engineer Department; four on the Survey of the United Kingdom; two attached to the General Post Office as telegraphers; three as Submarine Miners; six as Depôt Companies; and three in India. The distribution of the companies, and the present peace strength of the Corps, is given in Appendix (J). The officers of the *Troops* are kept for a certain time—that is to say from three to five years—with the same troop, so that they get to know something of the duties required of them, and of the men they have to command. The troops are stationed at one or other of the camps or at Chatham. The men are constantly being trained in the special work, to do which the troop exists. But the artificers execute all repairs, and the horses are employed on the public works, so that the organisation, while keeping men and equipment in a constant state of efficiency and readiness for active service, is an economical one for the country. For purposes of discipline, &c., the troops have their head quarters (with commanding officer and adjutant) and their depôt at Aldershot.

On the other hand, the officers with the *Companies* are frequently changed, and seldom get any hold over the men whom they are supposed to direct. For purposes of discipline the men are under the Commanding Royal Engineers of the districts where they may happen to be located. But where two or three are together, which is the case at one or two stations, it is customary to appoint a field officer to act as a sort of Commanding Officer of a Battalion. The men of the Companies undergo a training at Chatham, on first enlistment, in field operations, and the duties of a siege; but they have no annual or other course to go through. No Companies, except those who may happen to revisit Chatham in the course of their service, receive any further instruction; and the men, as well as the officers, are apt to forget what they once knew, and get rusty at the work which is the special business for which they enlisted, and which their country expects them to perform in a time of need.

When Engineers are required for war, their selection lies nominally with the Inspector-General of Fortifications; but, practically, the Deputy Adjutant-General, who is the senior Engineer Staff Officer in the Commander-in-Chief's office, has considerable voice in the matter. The equipment is the exclusive business of the Deputy Adjutant-General. Whether it be a Company or merely a detachment that is required, a certain amount of selection and consequent change has to be made in men and officers, and all the equipment has to be looked up and issued according to the supposed requirements of the campaign; so tha the body of Engineers that eventually sails has frequently to shake down and become organised as well as it can on the voyage.

It is the intention, in the event of a European war, to equip the Engineers of an Army Corps by breaking up B Troop (the Equipment Troop) into its component parts and attaching a Section to each of four Companies. Three of these Companies accompany Divisions, and one goes to Head Quarters as a Field Park. By this process it is expected that a Garrison Company will be transformed into a Field Company ready to move off at once with a marching army.

The detail of a Field Company so created, and of the Field Park, and also of a Pontoon and Telegraph Troop, are given in the Appendix (F, G, and H, and J).

The Staff of Engineers in an Army Corps is to consist of 1 Colonel, 1 Brigade-Major, and 1 A.D.C. There is, moreover, 1 Lieut.-Colonel, and 1 Adjutant with each Division, and with the Reserve.

V.—Proposed Changes in Organisation.

We now come to the 5th head into which I divided the subject.

Armed with the facts and data that I have collected, we will proceed to the discussion of the alterations that time and experience seem to suggest as necessary in the organisation of the Royal Engineers, to enable them best to fulfil their war duties, and at the same time maintain, as far as possible, their 'usefulness' in time of peace.

For convenience sake I will divide this part of the subject into the following questions.

1st. Judging from past experience what are the duties that the Royal Engineers should be capable of performing in time of war?

2nd. Can they fulfil these duties satisfactorily with their present organisation?

3rd. Is it well that they should, as a military body, be remunerative to the nation in time of peace? if so, how? and to what extent?

4th. What should be their future organisation?

1. *Duties of the Royal Engineers.*

The Engineers have been well called *the workmen* of the army. The General who employs them in any other way, unless in very exceptional circumstances, is making a bad use of the arms at his disposal. But the Engineers necessarily form a very small proportion of any army. And it is impossible for them, however zealous and however 'mobile,' to construct a tithe of the field works that the experience of modern war teaches us it is advantageous to make in the various phases of a campaign. Hence it is established as a rule in all well organised armies, that a certain proportion only of field works are to be made by the Engineers, and the rest by Infantry. And this leads us to the following questions: *how much* is to be done by each? How are the necessary tools to be carried? In whose charge are the tools to be? And who is to have the direction of the work? To answer these questions fully would be the work of another essay. To do so even in part would lengthen this one inordinately. Yet I cannot entirely pass the questions by, as on them depend, to a certain extent, the answers that I am giving to the original questions that I propounded; the first of which is, What are the duties of the Royal Engineers?

The more I study the experience of the past, the more I become convinced, that, unless the charge of the intrenching tools, and their carriage on the line of march, be the work of some special corps, they will seldom if ever be forthcoming when they are wanted. And I think that the natural troops to take charge of all intrenching tools required in the field are the Royal Engineers, *i.e.* those who not only have to work themselves on all possible occasions, but also have to direct working parties of Infantry when, during a lull in fighting, it is thought advisable to construct field works to any great extent. But there are numerous purposes for which an intrenching tool would be invaluable to an Infantry soldier; such as to protect himself by a shelter trench when, having advanced in skirmishing order, he is directed to hold some ground that he has won, or when he is on out-post duty; or, again, in camp life, to construct kitchens, drains, &c. And I think that every soldier should carry a trowel (or small intrenching tool) as part of his kit, the latter being lightened by doing away with some articles of far less value. As I said before, there is not space to discuss the 'pros and cons' of this question now. Perhaps it will be enough to recall the fact that a Pioneer's tool is one of the five things that Napoleon gives it as his opinion a soldier should *never be without*.

I will now tabulate the duties that the *Royal Engineers* should be able to perform in war, naming at the same time those field works that *Infantry* should be able to construct either alone, or in combination with, and under the direction of the Engineers.

A. *Works* which are required by a *moving army*, in the *presence of the enemy*:—(1) *Bridging*. (2) *Field Fortifications*. (3) *Pioneering*. (4) *Telegraphy*.

(1) *Bridging* includes all light as well as heavy bridges, which can be constructed *rapidly* from materials found on the spot, or carried to the front as rapidly as the workmen. Such bridges are the business of Engineers, either of Field Companies, or Pontoon Trains.

(2) *Field Fortifications* include—1st. Shelter trenches and shelter pits, loopholes, slight entanglements for outposts, &c., which can be constructed by Infantry (either with the *trowel*, which I would give them, or with tools supplied by the Engineers); and 2nd. Preparing villages for defence, attacking villages and posts (which comprises escalading, rapid demolitions, &c.), making extensive clearances, constructing redoubts, &c., which are the special duties of Engineers.

(3) *Pioneering* includes clearing away or creating obstacles, constructing or destroying roads, destroying bridges, &c., which are the work of Engineers.

(4) *Telegraphy*, in this case, is the construction of a temporary line to move with the advance of the army, and connect the advanced guard with the main body, and is the special work of Engineers.

B. Works required by a *stationary army*, in the *presence of the enemy*.

(1) The defence, or (2) siege of fortresses, and more or less permanent works.

(3) Submarine mining.

These duties include all the care of our garrison towns, harbours, Colonies, &c., which might be attacked in time of war.

(1) and (2) are performed by Engineers, assisted by Infantry and other working parties.

(3) Is the special work of the Engineer.

C. *Campaign Works*, such as the construction of bridges, roads, and railways, in rear of the moving army; of a semi-permanent telegraph line to connect with the movable one; of huts, hospitals, piers, wharves, wells, &c., which are all Engineer duties.

And field kitchens, drains, latrines, &c., in camps, which are made by the troops who require them.

N.B. The above works, although not executed in actual presence of an enemy, are subject to his attacks, and are not, therefore, devoid of danger.

D. Special Works, such as surveying, photography, printing, &c., for which certain Royal Engineers are trained in time of peace, and which they can consequently perform, if required, in time of war.

2. *Can the Royal Engineers fulfil their duties?*

Can the Royal Engineers fulfil the above duties satisfactorily with their present organisation?

I think that this question has been sufficiently answered by the review that we have made of our past history. Has it not been our faulty system of organisation that has given such incalculable difficulty to those officers who have frequently had to make bricks without straw? Our officers are energetic, and our men are good, and their labours have often covered defects. But it is unreasonable to expect that such can always be the case, especially if we are engaged in one of the rapid European wars of modern days. Where would the Germans have been without a sufficiency of mobile bridge trains in the early part of the war of 1870? Halted, perhaps, on the right bank of the Moselle sufficiently long to have enabled Bazaine to retire with his whole army, leaving Metz to be defended by its proper garrison: following slowly, along a line that crosses many rivers at right angles, to find the concentrated and re-organised armies of France in a strongly entrenched position on the road to Paris. . . . . Would not such a want have altered the whole phase of the war? perhaps the whole future of Europe?

Or, let us take our own latest experience—the Ashantee war. What would not the Commanding Royal Engineer on the coast of Africa have given for a few handy bridge constructors, and for some thoroughly trained Pioneers with their tools with them, in the fore front of the expedition? Would not such a provision have made the war less hazardous, less a matter of a few hours than it was, whether or not the British Force would be able to return to the protection of their ships without suffering some dire calamity?

We have seen how little prepared the French Engineers were before the last great war; how far even the careful Prussians were behind the requirements of the day in the way in which they used their Engineer force against Austria. Are *we* profiting by their experience? Modern war, as I have said before, requires *preparation beforehand*, because when it arrives it demands *great rapidity in action.*

It may, perhaps, be the feeling of some in England that our army, though small, is well organised and perfect as far as it goes. Even if such a feeling does really exist, let not *us* at all events—us, the Engineers of the army—be blind to *our* faults. Let us be ready to apply the pruning knife of reform *now* in the time of peace, that when war comes it may not find us unprepared.

3. *Should the Royal Engineers be remunerative to the country in peace time?*

Is it well that the Royal Engineers should, as a military body, be remunerative to the nation in time of peace? If so, how? and to what extent?

To the first part of this question I would answer, Yes; but *not* if by so being they lose one jot of their efficiency for war, which is the *primary* object of their existence. Great Britain requires a great number of Engineer officers in time of war to accompany expeditions, to garrison her Colonies and harbour forts, and to assist in the general defence of the kingdom at home and abroad. Hence it is thought advisable to keep a larger body than is actually required for military work in time of peace. The way in which this body is employed in peace time has already been shown. Those officers who are attached to men, and those on the staff are, as a rule, best prepared for war, and should be the first to be so utilised. Those employed in the Works Department would usually be required at their several stations; and in those situations would, in many cases, be taking an active part in the war. Still it is possible that, in a time of emergency, some of them could be spared for duties in the field. From the Works Department, therefore, should be taken the first reinforcements for the field army. Those officers who are employed in purely civil situations, may be considered as a reserve. Now, it cannot be denied that occupation is beneficial for everyone. But in the case of the Royal Engineers it must be borne in mind that the duties of a Military Engineer require activity of body as well as brain knowledge, and quickness of judgment as well as calm reasoning powers; and unless their civil occupation is of such a nature as not to destroy in them the above qualities, and at the same time allow them to keep up their military knowledge, the country will not benefit by it.

With reference to *the men*, it must be borne in mind that the system of short service, which has now been generally adopted for our army, has introduced a new phase into the question of the employment of soldiers on civil works. The army is now a large drill school, in which nearly the whole time of non-commissioned officers and privates is taken up in teaching or learning drill; and there is much less time than there used to be for anything else. This is the case, to a certain extent, with the Royal Engineers, who enlist for eight years, but whose instruction, it must be remembered, is far more comprehensive, and consequently takes longer than that of an Infantry soldier. Still they have a good deal of leisure time, during which they can be employed in the construction and repair of fortifications and barracks; and when this can be done without detriment to their military efficiency the country will profit by it. But a *certain proportion* of the Corps should be *always* in a state of training, and ready to proceed with a war expedition. This should be a *mobile force*, fully equipped, and capable of being divided as circumstances may require. In fact, there should be a body of Field Engineers ready to do the works detailed under the head *A* in the table of duties I have given. Those who would be required to execute works under the *other* heads need not be in such a state of *immediate* preparation; but their equipment should be thought out, and their organisation carefully laid down on paper, so that no unnecessary time would be lost in preparing them and fitting them out.

A word here as to the employment of the Corps in the Department of Public Works in India, and in the Royal Engineer Department in England and the Colonies.

With regard to the former, the works are large and important, and the conception and execution of them is left very much in the hands of the officers on the spot. Thus the minds of officers are enlarged, they become accustomed to superintend labour and to command their fellow-men, and they have every opportunity to keep sharp the tools of education that were supplied to them on entering their profession. Then the system of promotion by merit stimulates them to exertion; and the stirring life, associated as it is with occasional little wars, prevents a relapse into a listless state of unreadiness for active service. There is, moreover, a Native Engineer* organisation in each Presidency, which acts as a school to keep up the knowledge of Field Engineering duties. So that, although no doubt reforms are now and then required—where are they not?—yet there seems no reason to suggest any alteration in the system by which the Royal Engineers in India are employed and kept efficient for a time of war.

But with the Royal Engineer Department it is different. It has been

* The resources of the country in men and transport are immense; and, provided that a sufficient amount of tools and equipment were always kept ready, the Native Engineers in India could be very rapidly mobilised and rendered fit for war.

remarked that the employment of officers and men is, as a rule, advantageous both to the State who reaps the benefit of their services, and to those so employed. Yet I believe that there is nothing so damaging to the Corps as the present arrangement by which it is associated with the Works Department.*

* * * * *

In order to effect any reform in the corps the first thing to do is to *disassociate* it from its present connection with the Royal Engineer Department. It would be well, perhaps, to change the name of the latter, and let it be called what it *really* is, the 'Department of Works.' Let a certain number of Infantry and Cavalry officers be employed in it (as well as the Royal Engineers); say those who have passed the Staff College examination, and are willing to go through a course of construction at Chatham; † and let the promotion in the Department be, like that in the Indian Department of Public Works, by *merit*, and not by military rank.

The great proportion of officers employed in it would still, no doubt, be Engineers; but service in it would not be *compulsory*; an officer would know, when he entered it, what he was undertaking, and would work accordingly; and under such circumstances he would maintain himself in a far more efficient state for war than he does now. The Department itself, too, could not fail to benefit by a change that infused zeal and emulation among those it employed. And thus a mutual and increasing benefit would result to both Corps and Department.

The men of the Royal Engineers could be employed under it in its new state as easily as now. They would furnish daily working parties, in the same manner as Line Regiments do now, except that in the case of the Royal Engineers the officers would supervise their men at the works.

In detailing the working parties, however, a section (*i.e.* one-fourth) of each Company should be kept in constant training, under their own officers, in the duties required of them in war, so that they should not forget what they have learned, and should be ever ready for the purpose for which they were enlisted.

The 'Works Department' would, like other Departments (and like the Royal Engineer Department is now), be regulated by central authority, but be under the command of the General at each station.

* Its regulations are the only Royal Engineers standing orders, which every officer has to show as such at General's inspections.

† This would tend to destroy the argument that now holds for excluding the Royal Engineers from appointments on army staff and in army commands.

No better rules for its guidance could be laid down than those already promulgated under the title of Royal Engineer Department Regulations, which would require very slight modifications to fit them for the altered circumstances.

In addition to the Works Department, which would not, any more than it does now, *originate work*, but would merely be an *Executive* one, there would (as I propose) be an independent Engineer organisation, which will be described later on.

4. *What should be the Royal Engineers' Future Organisation?*

It has been said by a French writer, full of sad experience on account of the failure of the French organisation in the last war, that 'the least reflection upon the number of subjects that an officer of Engineers is now required to know, makes it difficult to deny that their range and variety is such as to defy any man's intelligence, energy, and quickness. An officer of Engineers must be acquainted with all matters relative to fortification and its armament. Further, he must have gone deeply into building-construction, roads, and hydraulic works. Henceforward he will have to familiarise himself more and more with railway work, telegraphy, and balloons. He must also know something of Infantry drill and duty; he must be a surveyor, a pontooner, an artillerist, a miner, a pyrotechnist; and even law must not be quite strange to him.' From this, and much other similar evidence, it may, I think, be assumed that it is *essential* to *efficiency* to separate the various duties that Engineers are required to perform, keeping the Corps together, under *one head*, for the sake of control, and in order to afford greater scope for selection.

In order to review thoroughly the alterations that I propose, let us commence from the top and work downwards.

The Inspector-General of Fortifications, relieved from the detail of the Works Department, would take his place on the Staff of the Commander-in-Chief. There he would form one of the Committee, which every nation should possess, to settle the general defence of the country. * * * Under the Commander-in-Chief, he would be the Commanding Officer of the Corps of Royal Engineers, regulating its distribution, and caring for its efficiency. He would, in his capacity of Inspector-General of Fortifications, inspect the various defences at home and abroad, be responsible for their efficiency, and bring forward any proposals for new forts or alterations in existing ones.

Under the Inspector-General there should be a certain number of

Inspectors chosen from among the best officers of the Corps, who would be detailed, each to look after a certain number of the home districts or Colonies (with perhaps two or three for India), and assist in inspecting and reporting upon the *personnel* of the Corps, including the Auxiliary and Reserve Engineers, as well as the fortifications and all works incidental to the general plan of defence.

Thus, the Quarter-Master General would, as now, be responsible for proposing any new *barrack* services; and the Inspector-General of Fortifications would do the same for *fortification* services; while the Works Department would act as the Royal Engineer Department does at present; and would be responsible for bringing forward all services of *renewal* and *repair*, carrying out besides such *new* services as the funds placed at its disposal enabled it to do.

Under the Inspector-General of Fortifications there should be one or more staff officers to assist him in the detail connected with the command of the men. But this work would be much reduced by establishing detached head-quarters for the different branches of the Corps. For instance, that for the Garrison Companies might be at Chatham; that for the Field Troops and Companies at Aldershot; that for the Submarine Mining Companies at Portsmouth; for the Survey Companies at Southampton; for the Telegraph Companies, and for a Company to include all foremen of works, clerks, and others employed regularly in the Works Department (and which might with advantage be increased to contain men for duty in detached forts, &c., like the Coast Brigade Artillery) in London.

Next, there should be on the staff of every General, in peace as well as war, an officer of Engineers, who would act as adviser on all points of fortification and field engineering, who could, if required, instruct troops in field works, who could assist his General in schemes for the defence of his district and the distribution of his troops, and should be capable of taking up the duty of any of the other staff officers if needed.

All *unemployed* officers of Royal Engineers should be stationed (or, at all events, borne on the muster-rolls) at one or other of the Head-Quarters, where they would have an opportunity to brush up their military knowledge; *and no officer should be placed in a position of responsibility* without giving satisfactory proof of his capability to perform all the duties that might be required of him.

To turn to the men. Looking to the facts and arguments that I have already given, it seems to me that it is absolutely essential to make and maintain a few *bonâ fide* Field Companies of Engineers. Perhaps four—the number authorised for an Army Corps—would be enough to keep permanently embodied. Their organisation is laid down in Army Circulars of 1875. (*See* Appendix H.)

But these Companies should not be made by attaching portions of an Equipment Troop to Garrison Companies *for a time only*, and then taking them away to go through the same process with others; but by making them complete in all their details, and similarly organised in every way to the existing Pontoon or Telegraph Troop.

These Field Companies should be stationed at the camps in England and Ireland. They should be regularly trained in field works under their own officers, but a portion of them (perhaps two-thirds) might be employed at works, either under the Works Department or in other ways; so that they would be as economical to the country as the present organisation. Thus they would be ready to take the field, in part or together, with any expedition that left our shores, and would, moreover, be fit for immediate use on landing.

It should be laid down as a maxim that an Engineer soldier, whether of a Field or Garrison Company, should *never* be *separated* from his tools and materials. Even in peace-time a small amount should accompany each detached body in order to accustom officers and men to their care, and to ensure Engineers being, under *all circumstances*, available for work. To send a body of Engineers to a war without tools is as anomalous as to send Artillery without guns, or Cavalry without horses, or Infantry without bayonets.

The unit of the Corps for all work should be the Troop or Company. In certain stations three or four might be collected; and there it would be advisable to combine them temporarily, and form a so-called Battalion or Regiment under a Commanding Officer, with, perhaps, a Major and an Adjutant. This would ensure uniformity in system and improve discipline. But care should be taken to keep up the *responsibility of all officers*, and even *non-commissioned officers*, down to the *smallest subdivision*; so that, when detached, as must be the case in war, those in command would be accustomed to the situation, and have no difficulty in carrying out the work that they had to do.

Our regular Engineers would, according to my suggestions, consist of (1) Troops for Pontoon and Telegraph work, organised as at present; (2) Field Companies, to accompany Infantry, and occasionally Cavalry, in the advance of a moving army, organised as I have explained; (3) Garrison Companies, for sieges, and to garrison fortified places, or for campaign works, organised as at present, but their establishment and equipment carefully detailed for peace and war, and a proportion of their peace equipment always with them; and (4)

Special Companies, such as Survey, Submarine Mining, and Postal Telegraph, organised as from time to time may be thought convenient, but their establishment and equipment laid down as in the case of the Garrison Companies.

The Volunteer Engineers, and any Militia Engineers that may hereafter be raised should be organised, I think, in Battalions of four Companies, two of which should be Field and two Garrison Companies. So that, on the outbreak of a great war, entailing their embodiment, the Field Companies might be sent at once to take their place in Army Corps raised for home defence, and the Garrison Companies sent to the fortresses. The model for these Companies should be those of the Royal Engineers. By this system the employment of the Field Officers of Volunteer Engineers could be regulated, as it would be an anomaly to place an untrained Volunteer in a position where by his superior rank he would command all the Royal Engineers in the same force. With regard, too, to the fact that for the whole British Army there is only one Pontoon Train (120 yards of bridge), or barely enough to cross a small river like the Thames at Windsor, and that pontoons of some kind are *an absolute necessity* for any moving army,* it would be well if two or three Volunteer Pontoon Trains were organised in the country on the model of the Regular one, Government supplying the pontoons and other equipment, and the Volunteers the men and horses.

I have not, in my suggestions, specified *numbers*, because I conceive it to be the business of the Statesmen of a country to establish the number of troops considered sufficient to uphold her honour and maintain her policy: to the Soldier being left questions of organisation and management. But, the principle having been established of creating an economical, and at the same time sufficiently large army by the system of short service and reserves, I may remark here that all attempts to re-organise the Royal Engineers will prove useless, unless men and horses are forthcoming to enable Troops and Companies of *war strength* to be made out of our present weak peace establishment. And a system should be elaborated by which Reserve men might know where they were to report in case of mobilisation, and officers commanding know where they would have to look to complete their cadres and get at all the necessary stores.

Let us see how, on the outbreak of war, our proposed organisation is capable of performing the duties required of it. The Engineer

* As much bridge is required for a small army as for a large one up to certain limits. That is, rivers are the same size for both to cross.

Staff for the army could be supplied at once by the Inspector-General, who would have a far more intimate knowledge of the Corps than he can have at present; and, their distribution being his special business, would know where most easily to find those best fitted to fill each required situation. The Field Companies could supply the first contingent to sail; and, with the Pontoon and Telegraph Troops, which are also always ready, could (as far as they go) undertake the duties that I have indicated above, under the head *A*, viz., bridging, field fortification, pioneering, and telegraphy. Behind the Field would come the Garrison and Submarine Mining Companies, who would be available either for the defence of our forts and harbours, or to undertake any protracted work, such as a siege in an enemy's country. When sent with a field army, and not employed at a siege, the Garrison Companies would be available for works under *head C*. In this case they would, probably, be temporarily attached to the Officer Commanding the Line of Communications. In addition to these there would be the Postal Telegraph Companies, who could supply an organisation to keep the advancing army in communication with its base, and the Survey Companies to supply what surveyors and printers were required. Finally, the Department of Works could find well qualified officers and foremen to execute the necessary works in rear of the army, which I have detailed under *head C*, and called *Campaign Works*. The Department would also carry on its usual duty, as well as any special works incidental to the occasion, in the various garrisons and fortresses, &c., under the orders of the General Officer intrusted with their defence.

To back the organisation which I have described, and which would be available for an enemy's country, and for the Colonies as well as for England, there are the Auxiliary Engineers to assist in our home defence.

Engineers, enlisted as they are from the artisan class, are perhaps more than any other troops congenial to the English character and English race. While, however, they have some good qualities, they also have their faults. By their energy and valour they gained a name in the Peninsula, and they kept it in the Crimea. But they are apt to be too confident in their own powers. Let us remember that the manner of war is changed; that organisation and rapidity are more necessary now than they were then. And let us endeavour to gain that rapidity, not by an attempt to imitate *unnecessarily* Cavalry or Artillery, but by rendering a portion of our force sufficiently 'mobile' to keep up with an advanced guard of all arms; by taking care that every required tool is in its place—not a nail wanting—at the hour of need; and by having officers and men thoroughly trained and efficient for their work.

Thus may we hope to emulate, perhaps even to surpass, the deeds of those who have gone before us; and so to act in the day of battle that the army and the people of England shall not have reason to be ashamed of their Engineers.

R. H.

APPENDIX A.

COMPANY OF ROYAL MILITARY ARTIFICERS AS CONSTITUTED BY THE ROYAL WARRANT OF OCTOBER 10, 1787.

		s.	d.	
1 Sergeant-Major	at	2	3	a day
3 Sergeants	,,	1	9	,,
4 Corporals	,,	1	7	,,
2 Drummers	,,	0	9	,,
12 Carpenters (Privates)	,,	0	9	,,
10 Masons ,,	,,	0	9	,,
10 Bricklayers ,,	,,	0	9	,,
5 Smiths ,,	,,	0	9	,,
5 Wheelers ,,	,,	0	9	,,
4 Sawyers ,,	,,	0	9	,,
8 Miners ,,	,,	0	9	,,
2 Painters ,,	,,	0	9	,,
2 Coopers ,,	,,	0	9	,,
2 Collar Makers ,,	,,	0	9	,,
30 Labourers ,,	,,	0	6	,,

Total—8 N.-C. Officers, 2 Drummers, and 90 Privates = 100.

Note—Working pay, not exceeding 9*d*. a day, was allowed to each N.-C. Officer and man for the days actually employed on the works.

APPENDIX B.

COMPANY OF ROYAL MILITARY ARTIFICERS BY WARRANT OF 1806.

*1 Sub-Lieutenant, at 5*s*. a day.
1 Sergeant-Major.
5 Sergeants.
5 Corporals.
*10 Second-Corporals, at 1*s*. 9*d*. a day.
30 Carpenters (including 4 Top Sawyers).
20 Masons }
18 Bricklayers } including Slaters, Tilers, and Plasterers.
10 Smiths.
10 Miners.
4 Wheelers.
4 Collar Makers.
2 Coopers.
2 Painters.
4 Drummers.

Total 126

* A new rank.

APPENDIX C.

COMPANY OF ROYAL MILITARY ARTIFICERS, OR ROYAL SAPPERS AND MINERS, IN 1811, 1812, AND 1813.

1	Sub-Lieutenant.
5	Sergeants.
5	Corporals.
5	Second-Corporals.
3	Drummers.
15	Carpenters.
10	Masons.
6	Bricklayers.
4	Smiths.
2	Wheelers.
2	Collar Makers.
1	Cooper.
30	Miners.
Total 89	

N.B. The rank of Company Sergeant-Major was abolished in May 1811.

ESTABLISHMENT OF CORPS, 1811.

4	Adjutants (never made).
4	Sergeant-Majors.
4	Quartermaster-Sergeants.
1	Drum-Major.
32	Sub-Lieutenants.
160	Sergeants.
160	Corporals.
160	Second-Corporals.
96	Drummers.
2,240	Privates.
Total 2,861	

Exclusive of the Maltese Military Artificers.

APPENDIX D.

WAR STRENGTH OF A COMPANY OF ROYAL ENGINEERS IN 1870–1.

1 Captain.
3 Lieutenants.
1 Assistant-Surgeon.
6 Sergeants.*
6 Corporals.
6 Second-Corporals.
2 Buglers.
26 Carpenters.
22 Masons.
11 Bricklayers.
9 Smiths.
3 Wheelwrights.
1 Cooper.
6 Painters.
3 Tailors.
3 Collar Makers or Shoemakers.
2 Clerks.
1 Printer.
2 Telegraphists.
1 Photographer.
10 Miners.

* *Note*—One Sergeant has *now* the rank of Company Sergeant-Major, and another that of Company Quartermaster - Sergeant, 1876.

Total—5 Officers, 120 N.-C. Officers and Privates.

The horses authorised are 10 chargers and 5 bát animals, provided by the officers and 2 pack animals (with pack saddles) provided by the public.

APPENDIX E.

SUMMARY OF THE VARIOUS DETACHMENTS AND BODIES OF GERMAN TECHNICAL TROOPS EMBODIED DURING THE CAMPAIGN OF 1870-71, EXCLUSIVE OF RESERVES.

I.—KINGDOM OF PRUSSIA.

(1) 36 Field Pioneer companies, each consisting of	5 officers. 1 medical officer. 212 men (including soldiers of the Train). 17 horses. 3 waggons (1 officers' equipment waggon, 1 tool waggon, and 1 powder waggon).
(2) 33 Garrison Pioneer companies, having each .	4 officers. 1 medical officer. 200 men (N.B. 30 of these companies were mobilised and provided with the same equipment in horses and waggons as the Field Pioneer companies).
(3) 12 complete Pontoon columns (not attached to companies), having each	2 Engineer officers, 63 pioneers } attached. 3 Train officers, 1 medical officer, 1 paymaster } in charge. 158 men. 277 horses. 41 waggons, with materials for not more than 160 metres of bridge.
(4) 12 Light Field Bridge Trains (each attached to one of the Field Pioneer companies of an Army Corps).	2 Train officers. 51 men. 87 horses. 13 waggons, with materials for about 58 metres of bridge.
(5) 12 intrenching columns (each attached to one of the field companies of an Army Corps).	18 men. 30 horses. 6 waggons (laden with 1,200 spades, 300 pickaxes, 180 axes, &c.)

TELEGRAPH DETACHMENT.

(6) 7 Field Telegraph detachments, having each	3 Engineer officers. 1 medical officer. 1 field telegraph inspector. 6 field telegraph clerks. 101 pioneers. *Telegraph Train.* 1 Train officer. 34 men. 82 horses. 12 waggons.

TELEGRAPH DETACHMENT.

(7) 5 Etappen Telegraph detachments, having each (Each divided into two sections, viz. 1st section for new work, 2nd section for reconstruction).	1 Engineer officer. 2 telegraph inspectors. 10 clerks. 41 pioneers and soldiers of the Train. 24 telegraph workmen. *Telegraph Train.* 1 Train officer. 46 men. 139 horses. 16 waggons.

RAILWAY COMPANY.

(8) 5 Field Railway detachments, having each .	3 Infantry officers. 1 Engineer officer. 186 men (including 75 pioneers). 16 horses. 2 waggons. *Technical Railway Staff.* 1 principal officer. 19 officials. 24 foremen. Corps of labourers, varying in number.

(9) Torpedo detachments.	(a) Not mobilised, each having	5 Engineer and Naval officers. 80 pioneers. 10 sailors. Working parties supplied by the Garrison Pioneer companies and the Navy.
	(b) Mobilised, each having	2 Engineer officers. 1 medical officer. 55 pioneers. 27 sailors. 5 horses. 1 waggon.

(10) Balloon detachment	2 Engineer officers. 42 pioneers.
(11) Field Photographic detachment.	2 Engineer officers. 11 pioneers.

II.—KINGDOM OF BAVARIA.

(1) 2 Field Engineer divisions, having each .	Staff, 3 Field Engineer companies, and 1 Field Telegraph detachment, containing altogether— 18 officers. 1 medical officer. 703 men, including drivers. 346 horses. 46 waggons (including 2 bridge equipments of 15 waggons each, 2 pioneer equipments of 4 waggons each, 1 telegraph equipment of 3 waggons). N.B. In September 1870 1 bridge equipment of 15 waggons was added to each Field Engineer division.
(2) 1 Garrison Engineer division, consisting of .	Staff and 2 Garrison Engineer companies, containing altogether— 12 officers. 1 medical officer. 476 men, including drivers. 155 horses. 20 waggons (including 2 pioneer equipments of 4 waggons each, 2 sapper and miner equipments, and 2 field smithies, having together 6 waggons).
(3) 1 Garrison Engineer company.	4 officers. 194 men. 3 horses. 1 waggon.
(4) 1 Etappen Engineer company.	5 officers. 167 men. 52 horses. 5 waggons (including 1 pioneer equipment).
(5) 1 Etappen Telegraph detachment.	2 officers. 62 men. 12 horses. 2 waggons.

RAILWAY COMPANY.

(6) 1 Railway detachment.	4 Engineer officers. 181 men. 60 horses. 1 railway equipment. *Technical Railway Staff.* 1 director. 17 officers and station-masters. 20 foremen.

III.—KINGDOM OF SAXONY.

(1) 3 field pioneer companies. (2) 1 pontoon column. (3) 1 light field bridge-train. (4) 1 intrenching column.	Organised like the Prussian.

IV.—KINGDOM OF WURTEMBURG.

(1) Pioneer corps. 1 pioneer company and 1 sapper company, with bridge-train and intrenching column).	Staff and 2 companies together. 12 officers. 415 men. 170 horses. 31 waggons.
(2) Field Telegraph detachment. (Attached to the Pioneer corps.)	2 officers. 1 telegraph inspector. 6 telegraphists. 40 men (including Train soldiers). 31 horses. 5 waggons.
(3) Garrison Engineer company.	5 officers. 165 men. 8 horses. 1 waggon.

V.—GRAND-DUCHY OF BADEN.

(1) 1 field pioneer (pontoon company). (2) $\frac{1}{2}$ pontoon column. (3) 1 light field bridge-train. (4) $\frac{2}{3}$ ditto of an intrenching column. (5) 1 garrison pioneer company.	Organised, in general, like the Prussian.

VI.—GRAND-DUCHY OF HESSE.

1 Pioneer company (with light field bridge-train).	5 officers. 1 medical officer. 211 men. 167 horses. 18 waggons (including 12 bridge-Train waggons).

APPENDIX F.

ROYAL ENGINEERS.—PONTOON TROOP.

DETAIL OF ONE PONTOON TROOP, WAR ESTABLISHMENT.

(*As authorised by Army Circulars of* 1875.)

Officers and Men

	No.
Major (director of bridging)	1
Captain, Assistant	1
Lieutenants, Assistant	4
Quartermaster	1
Surgeon	1
Veterinary Surgeon	1
	9
Non-commissioned Officers and Men.	
Troop Sergeant-Major	1
Troop Quartermaster-Sergeant	1
Sergeants	10
1st Corporals	12
2nd Corporals	12
Pontoniers	100
Drivers	150
Trumpeters	2
Articifiers	
Farrier and Carriage Smith	1
Sergeant Artificer	1
Corporal Artificers	3
Shoeing and Carriage Smiths	8
Collarmakers	4
Wheelers	4
Carpenters	4
Total	322

Horses, Saddlery, and Harness

Horses.	No.
Riding.	
Officers	*18
Staff-Sergeants	2
Non.-Com. Officers	12
Farrier	1
Shoeing Smiths	2
Trumpeters	2
Spare	1
	38
Draught.	
Waggons: Pontoon	120
Waggons: Trestle	24
Waggons: Store	30
Waggons: Office	4
Waggons: Forge	6
Spare	24
Total horses	246
Saddlery Sets.	
Officers'	8†
Non.-com. officers'	20
Harness.	
Double sets, wheel, R.E. pattern	104

Equipment

Carriages.	No.
Waggons: Forge	1
Waggons: Office	1
Waggons: Pontoon	20
Waggons: Trestle	4
Waggons: Store	5
Total	31
Artificers' Tools.	
Carpenters' . sets	2
Collarmakers' „	4
Farriers' „	1
Painters' „	3
Smiths', G.A.S., with 36-lb. vice . sets	1
Tinman's „	1
Tools, shoeing, in leather case . sets	4
Wheelers' and saddle-tree makers . sets	1
Whitworth stocks and dies, $1\frac{1}{8}''$ to $\frac{1}{4}''$, with tray . sets	1
Materials for Repairs.	
Carpenters', Collarmakers', Saddle-tree-makers', Smiths', Tinsmiths' and Wheelers'	Sufficient for 3 months.

* All private property. † The Veterinary Surgeon provides his own saddlery.

APPENDIX G.

ROYAL ENGINEERS.

DETAIL OF ONE TELEGRAPH TROOP, WAR ESTABLISHMENT.

(As authorised by Army Circulars of 1875.)

Officers and Men	Right Half-troop	Left Half-troop	Total for One Troop
OFFICERS.			
Major	1	—	1
Captain	—	1	1
Lieutenants	2	2	4
Quartermaster	1	—	1
Surgeon	1	—	1
Veterinary Surgeon	1	—	1
	6	3	9
NON-COMMISSIONED OFFICERS AND MEN.			
Troop Serg.-Major	1	—	1
Troop Q.M.-Serg.	1	—	1
Sergeants	4	6	10
1st Corporals	5	4	9
2nd Corporals	4	5	9
Sappers	45	45	90
Drivers	64	61	125
Trumpeters	1	1	2
ARTIFICERS.			
Farrier and Carriage Smith	1	—	1
Serg. Artificer	—	1	1
Serg. Telegrapher	1	—	1
Corp. Artificers	1	1	2
Corp. Telegraphers	2	2	4
Shoeing and Carriage Smiths	2	3	5
Collarmakers	2	1	3
Wheelers	2	1	3
Carpenters	1	2	3
Telegraphers	6	6	12
Totals	149	142	291

Horses, Saddlery, and Harness	Right Half-troop	Left Half-troop	Total for One Troop
HORSES.			
Riding.			
Officers'	12*	6*	18*
Staff-Sergeants'	2	—	2
Non-Com. Officers'	6	8	14
Signallers'	12	12	24
Farrier's	1	—	1
Shoeing-smith's	—	1	1
Trumpeters'	1	1	2
Total	34	28	62
Draught.			
Waggons – Wire	36	36	72
Waggons – Office	8	8	16
Waggons – Store	8	8	16
Waggons – Boat	4	4	8
Waggons – Forge	4	4	8
Spare	8	8	16
Total Horses	102	96	198
SADDLERY SETS.			
Officers'	5†	3	8
Non.-Com. Officers' and Signallers'	22	22	44
HARNESS.			
Double sets, wheel, R.E. pattern	34	34	68
Pack	1	1	2

Equipment	Right Half-troop	Left Half-troop	Total for One Troop
CARRIAGES			
Wire	6	6	12
Telegraph Office, R.E. pattern	2	2	4
Store	2	2	4
Boat	1	1	2
Forge	1	1	2
Total	12	12	24
ARTIFICERS' TOOLS.			
Carpenters' sets	1	1	2
Collarmakers' "	2	2	4
Farriers' "	1	1	2
Painters' "	1	1	2
Smiths' "	1	1	2
Telegraphers' "	9	8	17
Wheelers' & Saddle-tree Makers' sets	1	1	2
Whitworth's stocks and dies sets	1	1	2
MATERIALS FOR REPAIRS.			
Carpenters', Collarmakers', Smiths', Wheelers' and Saddle-tree Makers'	Sufficient for 3 months.		

* All private property.

† Veterinary Surgeon provides his own saddlery.

APPENDIX H.

ROYAL ENGINEERS.

DETAIL OF ONE COMPANY AND FIELD PARK, WAR ESTABLISHMENT.

(*As authorised by Army Circulars of* 1875.)

Officers and Men	Company	Field Park	4 Co.'s and Field Park
OFFICERS.			
Major	1	—	4
Captain	1	—	—
Lieutenants	3	1	17
	5	1	21
NON-COMMISSIONED OFFICERS AND MEN.			
Sergeants	7	1	29
Corporals	7	1	29
2nd Corporals	7	1	29
Sappers:— Carpenters 32, Masons 28, Bricklayers 14, Smiths 14, Wheelwrights 4, Coopers 2, Painters 6, Tailors 4, Collarmakers or Shoemakers 4, Clerks 3, Printer 1, Telegraphers 2, Photographer 3, Miners and Quarrymen 22	137	—	548
Drivers	16	18	82
Buglers	2	—	8
Spare Men, Bâtmen, &c.	10	2	42
Total	186	23	767

Horses, Saddlery, and Harness	Company	Field Park	4 Co.'s and Field Park
HORSES.			
Riding.			
Officers	10	2	42*
Non-Com. Officers	3	3	15
Buglers	1	—	4
Spare	—	2	2
Total	14	7	63
Draught.			
Wagons: General Service	24	20	116
Wagons: Office	—	4	4
Wagons: Miners	—	4	4
Wagons: Printing	—	4	4
Wagons: Photographic	—	4	4
Pack Equipment	4	—	16
Spare	4	2	18
Total Horses	46	45	229
SADDLERY. SETS.			
Officers'	5	1	21
Non-Con. Officers'	4	5	21
Pack Saddle, sets	4	—	16
HARNESS.			
Double sets, wheel R. E. pattern	14	19	75

Equipment	Company	Field Park	4 Co.'s and Field Park
CARRIAGES.			
General Service	6	5	29
Office	—	1	1
Miners	—	1	1
Printing	—	1	1
Photographic	—	1	1
Total	6	9	33
ARTIFICERS' TOOLS. SETS.			
Painters, as approved 12th June, 1867, 54 (Engs.) 2818	1	1	5

MATERIALS FOR REPAIRS.

Collarmakers, Saddle-tree Makers, Smiths', Wheelers' and Carpenters', Miscellaneous	Sufficient for 3 months.

* All private property.

APPENDIX J

ESTABLISHMENT OF ROYAL ENGINEER COMPANIES AS PER ARMY ESTIMATES OF 1876.

Establishment	One Ordinary Company	One Survey Company	40 Companies*	Pay per diem†
				s. d.
Sergeant-Majors	—	—	4	4 7½
Employed in the Department of Works‡: Sergeant-Majors as clerks	—	—	14	2 9½
Employed in the Department of Works‡: Quartermaster-Sergeants as clerks	—	—	28	2 9½
Employed in the Department of Works‡: Sergeants as clerks	—	—	42	2 9½
Employed in the Department of Works‡: Sergeant-Majors as Foremen of Works	—	—	30	2 9½
Employed in the Department of Works‡: Quartermaster-Sergeants as Foreman of Works	—	—	60	2 9½
Employed in the Department of Works‡: Sergeants as Foremen of Works	—	—	92	2 9½
Sergeant-Major as Instructor	—	—	1	2 9½
Band Master	—	—	1	5 7
Quartermaster Sergeants	—	—	4	4 1½
‡Sergeants Instructors	—	—	19	2 9½
‡Sergeants Instructors of Volunteers	—	—	15	2 9½
‡Drill Sergeants	—	—	2	2 9½
‡Sergeants Instructor of Musketry	—	—	2	2 9½
Bugle-Major	—	—	1	4 1½
‡Armourer-Sergeant	—	—	1	2 9½
Company Sergeant-Majors	1	1	40	3 3½
‡Sergeant Cook	—	—	2	2 9½
Sergeants	5	7	217	2 9½
‡Band Sergeant	—	—	1	2 9½
Trumpets and Buglers	2	2	80	1 1½
Total Non-Commissioned Officers, &c.	8	10	656	
Corporals	6	8	258	2 1½
‡Corporals as Volunteer Instructors	—	—	15	2 1½
2nd Corporals	6	8	270	1 10
Sappers and Miners	73	87	2,952	1 1½
Total Rank and File	85	103	3,495	
Total all ranks	93	113	4,151	

* Three Companies on Indian Establishment not included.
† Pay since raised.
‡ These men receive special, or departmental pay, or perquisites. The others receive working pay when on the works.

APPENDIX J (*continued*).

ESTABLISHMENT OF ROYAL ENGINEER TROOPS AS PER ARMY ESTIMATES OF 1876.

Establishment	Depôt	3 Troops	Pay per diem†
			s. d.
Acting Adjutant	—	—	3 6
Riding Master	1	—	9 0
Veterinary Surgeons	2	—	10 0
* Total Officers	3	—	
Sergeant-Major	1	—	4 11
Quartermaster-Sergeant	1	—	4 11
Staff Farrier and Carriage Smith Major	1	—	4 1
Troop Sergeant-Majors	—	6	3 10
Sergeants	3	24	3 1
Sergeant Farriers and Shoeing Smiths	—	3	3 3
Sergeant Artificers	—	4	3 3
Trumpeters and Buglers	—	9	1 4
Total Non-Commissioned Officers, &c.	6	46	
Corporal Artificers	—	9	2 7
Shoeing Smiths	—	17	1 11
Collar Makers	—	7	1 11
Wheelers	—	7	1 11
Artificers	—	18	1 11
Corporals	3	26	2 5
2nd Corporals	3	27	2 1
Sappers	10	242	1 4
Drivers	15	283	1 4
Total Rank and File	31	636	
Total numbers	40	682	
Horses	422		

* This is exclusive of the regular officers who are included in the general list given elsewhere.
† Pay since raised.
None of the above receive working pay.

APPENDIX J (*continued*).

DISTRIBUTION OF ROYAL ENGINEER TROOPS AND COMPANIES, DECEMBER 1876.

Troop or Company	Station	Officers	Troop or Company	Station	Officers
A Troop (Pontoons)	Aldershot & Chatham	1 Major 4 Lieuts.	21st Comp.	Malta	1 Capt. 4 Lieuts.
B Troop (Equipment)	Aldershot	1 Capt. 4 Lieuts.	22nd Comp. (G.P.O. Tel.)	London	1 Major 2 Lieuts.
C Troop (Telegraph)	Aldershot	1 Major 4 Lieuts.	23rd Comp.	Cork Harbour	1 Capt. 3 Lieuts.
1st Comp.	Shorncliffe	1 Capt. 2 Lieuts.	24th Comp.	Malta	1 Capt. 3 Lieuts.
2nd Comp.	Chatham	1 Capt. 2 Lieuts.	25th Comp.	Gibraltar	1 Capt. 2 Lieuts.
3rd Comp.	Gibraltar	1 Capt. 2 Lieuts.	26th Comp.	Halifax, N.S.	1 Capt. 3 Lieuts.
4th Comp. (Submarine Miners)	Chatham & Bermuda	1 Capt. 5 Lieuts.	27th Comp.	Aldershot	1 Capt. 2 Lieuts.
5th Comp.	Portsmouth	1 Capt. 1 Lieut.	28th Comp. (Sub. Mining)	Portsmouth & Chatham	1 Capt. 5 Lieuts.
6th Comp.	Fiji	1 Capt. 1 Lieut.	29th Comp.	Gibraltar	1 Capt. 2 Lieuts.
7th Comp.	Cape of Good Hope	1 Capt. 1 Lieut.	30th Comp.	Chatham	1 Capt. 1 Lieut.
8th Comp.	Gibraltar	1 Capt. 3 Lieuts.	31st Comp.	Chatham	1 Capt. 2 Lieuts.
9th Comp.	Glasgow	1 Capt. 3 Lieuts.	32nd Comp.	Bermuda	1 Capt. 2 Lieuts.
10th Comp.	Bermuda	1 Capt. 2 Lieuts.	33rd Comp. (Sub. Mining)	Devonport, Cork, and Malta	1 Capt. 5 Lieuts.
11th Comp.	Bermuda	1 Capt. 2 Lieuts.	34th Comp. (G.P.O. Tel.)	Ipswich	1 Capt.
12th Comp.	Bermuda	1 Capt. 3 Lieuts.	35th Comp. (Depôt)	Chatham	1 Capt. 1 Lieut.
13th Comp. (Survey)	Inverness and Ireland	1 Capt. 2 Lieuts.	36th Comp. (Depôt)	Chatham	1 Capt. 2 Lieuts.
14th Comp. (Survey)	Oxford and Plymouth	1 Capt. 2 Lieuts.	37th Comp. (Depôt)	Chatham	1 Capt. 1 Lieut.
15th Comp.	London	1 Capt. 1 Lieut.	38th Comp. (Depôt)	Chatham	1 Capt. 1 Lieut.
16th Comp. (Survey)	Reading	1 Capt. 2 Lieuts.	39th Comp. (Depôt)	Chatham	1 Capt. 1 Lieut.
17th Comp.	Curragh	1 Capt. 2 Lieuts.	40th Comp.	Chatham	1 Capt. 2 Lieuts.
18th Comp.	Cork Harbour	1 Capt. 1 Lieut.	41st Comp.	Roorkee, India	1 Lieut.
19th Comp. (Survey)	Edinburgh	1 Capt. 2 Lieuts.	42nd Comp.	Bangalore, India	1 Capt.
20th Comp.	Portsmouth, ordered to Malta	1 Capt. 1 Lieut.	43rd Comp.	Kirkee, India	1 Capt.

SUMMARY.

3 Troops in England, with 2 Majors, 1 Captain, and 12 Lieutenants.
17 Service Companies in England and Ireland, with 17 Captains and 28 Lieutenants.
17 Service Companies abroad, with 16 Captains and 32 Lieutenants.
4 Survey Companies in England, with 4 Captains and 8 Lieutenants.
3 Submarine Mining Companies at home and abroad, with 3 Captains and 15 Lieutenants.
2 G.P.O. Telegraph Companies in England, with 1 Major, 1 Captain, and 2 Lieutenants.
Total—3 Troops, 43 Companies, 3 Majors, 45 Captains, and 97 Lieutenants.

APPENDIX K.

EXTRACTS FROM THE QUEEN'S REGULATIONS.

SECTION V.

Paragraph 47.—The Inspector-General of Fortifications, who is also the Director of Works, is to be considered as a General Officer on the Staff of the army, holding the position of a Divisional General as regards the Corps of Royal Engineers, at the same time that he conducts the department connected with Military Engineering, Fortifications, Barracks and other works.

Paragraph 48. The Inspector-General of Fortifications will advise the Commander-in-Chief on all questions relating to the employment and technical instruction of the Royal Engineers; and will submit to him all general arrangements relating to the distribution both of the officers and men of the Corps. He is empowered to make his inspections, and submit recommendations regarding the Corps at such times as he may think proper.

Paragraph 49.—Subject to the general supervision of the Inspectors-General of the two Corps, and to their responsibility to the Commander-in-Chief as commanding officers of corps, for the military discipline of the officers and men under their command, the officers commanding Royal Artillery and Royal Engineers are further charged with the following special duties, viz.:

(*a*) The officer commanding the Royal Artillery in a district or station is charged with the care and preservation in a state of efficiency of the armaments mounted in fortresses, and of all guns, ammunition, and artillery *matériel* in charge of the officers and men under his orders. He will put forward, in the prescribed manner, requisitions for keeping these armaments and stores up to the regulated proportions. At foreign stations the inspectors of warlike stores is under the orders of the officer commanding Royal Artillery in regard to his duties as inspector.

(*b*) The Commanding Royal Engineer is responsible for the superintendence and charge of the lands, works, roads, fabric of military buildings, and property of the War Department within his district; also for the efficient direction and control of the professional duties assigned to the Corps of Royal Engineers, such as the conduct of engineering operations at sieges, the superintendence and execution of all field works, the working arrangements of all permanent military telegraph stations, electric and visual, as well as the construction of military telegraphs; and for mining, bridging, the making of surveys, and such other military engineering duties as the general officer under whom he is serving may direct.

Paragraph 50.—In addition to the duties which devolve separately on the officers commanding the Artillery and Engineers, these officers are conjointly responsible for the Artillery and Engineer arrangements appertaining to the attack and defence of fortified places. The intimate connection that exists between the Artillery and Engineer branches of the service renders necessary the most cordial co-operation on the part of the officers in command.

Paragraph 51.- When projects for attack and defence, or for alterations to existing defensive batteries or armaments are being prepared, the commanding officers of Artillery and Engineers should consult together and jointly consider the character, position, and relative importance of the offensive or defensive batteries, the number and nature of the guns, their direction of fire, the number of traverses, and position and size of magazines, shell rooms, and other buildings required for artillery purposes. It will be the duty of the Engineer to design the batteries to meet as far as circumstances will admit, the requirements of the Artilleryman. Should there be difference of opinion, any remarks which the Commanding Officer of Artillery may have to offer upon the subject should accompany the plan when transmitted for approval.

Paragraph 52—When it is necessary to make proposals respecting new armaments, or changes in existing armaments, the Commanding Officer of Artillery and Engineers will prepare a joint report, which, with illustrative plans, will be forwarded through the General Officer commanding to the Adjutant-General for submission to the Commander-in-Chief and Secretary of State for War. Such report is to be headed with a statement of the number and nature of the guns in the work under consideration, as also an outline of the work itself, if it be not too large and complex in form. Whenever any guns are mounted in the defences upon local authority, a report of the circumstances is to be made by the General or other officer commanding to the Adjutant-General for the information of the Commander-in-Chief and the Secretary of State for War; and, except under very special circumstances, before guns are demanded from store to be taken over by the Royal Artillery for the purpose of being mounted, the sanction of the Secretary of State for War and the Commander-in-Chief is to be applied for through the Adjutant-General.

PAPER XV.

PRIZE ESSAY, 1881.

By Lieut. R. da Costa Porter, R.E.

'WARFARE AGAINST UNCIVILISED RACES; OR, HOW TO FIGHT GREATLY SUPERIOR FORCES OF AN UNCIVILISED AND BADLY-ARMED ENEMY.'

It has been asserted that the art of war is an exact science in which, when all the conditions are foreknown, the result may be predicted. As an abstract theory this may be true; in practice it is absolutely false. *All* the conditions never can be known, and even when they are so, each problem may present as many solutions as an equation of a high degree. But if, in ordinary civilised warfare, the conditions are so much surrounded with uncertainty, how much more so is it the case in savage warfare. To attempt to reduce to rule the campaigns that have been, and yet may be, carried on against our numerous uncivilised neighbours, would prove a hopeless task. Each new campaign as it is fought exposes to our gaze a new form of warfare, and the experience gained by our predecessors is but partially applicable to ourselves. The strategy of an Afghan campaign must differ from that of a New Zealand war; the tactics fitted for the bush fighting of Ashanti would not be suitable for the open plains of Ulundi. Each campaign that we have fought has a character all its own. The peculiar conditions in every case have produced special features in each expedition; and as it has been in the past, so undoubtedly will it be in the future.

But much as our past savage wars may differ from each other, there are certain points of common resemblance. Certain main principles run through them all, which may serve as guides in future cases. These it may be worth while to note, to underline, as it were, and bring into proper prominence. It is not possible to hope to carry on campaigns by rule. The individual genius of the commander must be called into play, a genius which, while willing to learn from the past experience of others, has sufficient initiative to deal with new cases as they arise. Every writer on the art of war must therefore be content to draw attention merely to those fundamental principles which apply to the class of campaigns he is considering. Where, leaving general principles, he proceeds to special cases, he must remember that his examples only apply where the conditions are similar.

In the following pages, therefore, I intend chiefly to deal with first principles as far as they can be deduced from actual experience. In quoting examples, it will be found that I shall draw largely from the late Zulu campaign, and I shall do so for several reasons. In the first place, that is the only experience I have had of actual warfare, and I believe that one example drawn from what one has seen is often worth many culled from books. In the second place, I believe that when the subject for this essay was determined on, the Zulu war, and expeditions like it, were in the thoughts of those who had to make the selection. But, while taking many examples from that campaign, I do not intend by any means to confine myself to it. I shall have occasion to mention frequently the wars in New Zealand, Abyssinia, Ashanti, and Afghanistan. These all teach valuable lessons, and much that is useful may be drawn from them.

The first point to which I wish to draw attention is that, notwithstanding the peculiar conditions of campaigns in savage countries, many of the ordinary rules of warfare do still apply in the majority of cases. As an example I will take the line of communication with the base of operations.

It is a well-known rule of war that an army working on a front parallel to its line of communication with its base is in a very disadvantageous position.* Now, at the commencement of the Zulu war the 3rd column, under Col. Glyn, was stationed at Helpmakaar and Rorke's Drift, preparatory to an advance *viâ* the line Isandhlwana, Isepezi, Ulundi. Its ultimate base was Durban, with which it communicated by the line Helpmakaar, Greytown, Maritzburg, Durban. From Durban to Greytown this line lay at a considerable distance from the frontier, and its exposed flank was protected by the 1st column on the Lower Tugela, the 2nd column at the Middle Drift,

* Hamley's *Operations of War*, Part III., chap. ii.

and the border guard along the line of the Tugela. Above Greytown, however, it approached the Zulu border, and from thence to Helpmakaar, ran parallel to it at a distance of from eight to ten miles from it. At any point between these places, for a distance of sixty miles, it was exposed to any incursions the enemy might choose to make upon it. Owing to the peculiar nature of the war, it was impossible at that time to obtain any information as to the Zulu movements, and it was always possible for them to assemble an "impi" and cross the river before any warning could be given of their intentions. At first no inconvenience was felt from this danger. The experience of the Old Colony War induced everyone to despise the enemy, and to reject as impossible the idea of his assuming the offensive. Nor did he do anything to disturb this delusion. Consequently unprotected convoys, single companies of infantry, and small parties of all kinds were perpetually moving along this road without fear of danger. But the news of Isandhlwana at once changed all this, and awoke everyone along the road to a sense of his danger. At Umsinga was a convoy of 35 waggons carrying, among other things, the reserve ammunition of the column, and guarded by only 24 men. Exposed as it was to an attack, at that time apprehended by everyone, the native drivers took fright and bolted; the convoy could not proceed, and had the Zulus shown the slightest energy, the loss of this ammunition (more than ever necessary for the safety of the column after the capture of the camp at Isandhlwana) must have ensued. Thirty miles lower down, at the Mooi River, and within eight miles of the border, was the only company of Engineers belonging to the column, and with them was the only remaining Engineer park. An attack on this company, as it marched through the broken bush country between Mooi River and Umsinga, could hardly have failed to be successful. Two marches lower down, at Greytown, were two companies of the 4th King's Own, who also had this dangerous road to traverse. Col. Bray, C.B., the officer commanding at Umsinga, called up the Engineers and the 4th King's Own to his assistance, and at the same time issued an order that the road should be considered closed thereafter, and that all convoys arriving from Maritzburg should take the Ladysmith road, which, from its distance inland, was far safer. In drawing attention to these facts I am far from wishing to criticise those who chose the Greytown road as a line of communication. There were many reasons, I am aware, why this line was the most convenient as a mere road by which to bring supplies to Rorke's Drift, the point at which the crossing into Zululand was to be made. I wish, however, to point out that even in savage warfare any departure from the ordinary rules may frequently entail grave dangers, and that before determining on such a departure it is well to consider what those dangers may be. Circumstances may, of course, compel us to do that which of our own free wills we would not do, or manifest advantages to be gained may induce us to incur some little risk voluntarily. At the same time it is but right to remember that most of the fundamental rules of warfare are as applicable to a Zulu or an Ashanti expedition as to a European war. If we find it necessary or advisable to break those rules we can only do so at a certain appreciable risk, and before doing so we should take that risk into our calculations.

Primary Base.

The first requisite before commencing a campaign must be the provision of a safe base of operations. As an ordinary rule, in all expeditions of the nature under consideration, this will be formed at the port of disembarkation, as Annesley Bay in the Abyssinian, Cape Coast Castle in the Ashanti, and Durban in the Zulu expeditions. Sometimes, it is true, a new base may be formed farther up country before commencing actual hostilities, as, for instance, Dundee and Conference Hill before the advance to Ulundi. But owing to the fact that every expedition sent from England must proceed by sea, the place of disembarkation naturally points itself out as a primary base. There all men and supplies must first of all be sent, and there must all the staff of a base be maintained; this fact is of some importance in determining the amount of stores that should be sent with an expedition from England. When the troops advance they may have to cut down their transport to a *minimum*, and consequently they may take up country but a small amount of material and supplies. But the distance from the home country, at which these wars are usually fought, points to the wisdom of having near at hand not only what is *certain* to be wanted, but also much which *may* be wanted, however small the chance of its being required. On this point Colonel Home, R.E., says:—'When this country makes war, her base of operations must be some place beyond the sea, and officers in charge of such operations as those that fell to my share, would do well to remember that a liberal supply of tools and material costs merely their transport or freight to the point of disembarkation.'* I do not intend in this essay to discuss what stores should be sent, least of all what engineer stores; this must depend greatly upon the nature of the country in

* *Engineer Operations on the Gold Coast.*

which the operations have to be undertaken; and besides, I understand the object of this essay to be rather the discussion of the general principles of strategy and tactics to be employed than the details of organisation. Here I only point out that the primary base will be the point of disembarkation. It is essential, however, that this base should be safe from all inroads of the enemy. Sometimes mere distance from the scene of operations is sufficient for this purpose, as was the case with Durban and Annesley Bay. But sometimes the enemy's proximity will render it necessary to take special precautions. Thus the first care of Colonel Home in the Ashanti War was to place Cape Coast Castle in a state of defence.

Advanced Base.

When the distance to the scene of operations is considerable the formation of an advanced base becomes necessary. This should be placed at or as near the frontier as may be, and its organisation should be completed before any further movements are attempted. In this advanced base are accumulated sufficient stores to enable the army to carry out at least those operations that are first decided upon, so that no check may be subsequently sustained while fresh supplies are being brought up. Here, even more than at the primary base, is it necessary to fortify the post, and render it secure against any attempts of the enemy. Thus the hasty entrenchment of Rorke's Drift alone enabled Major Chard, V.C., R.E., to make the successful defence by which that advanced base was saved the night after Isandhlwana. Had that post fallen, the position of the retreating 3rd column would have been insecure to the last degree. Its maintenance afforded a resting-place to our beaten soldiery, and rendered unnecessary a prolonged retreat without supplies.

Plan of Campaign.

In laying down a plan of campaign for an expeditionary force, the greatest difficulty is sometimes felt from the want of a vital point at which to strike. The absence of a capital of prime importance to the country, the peculiar nature of the enemy's army, which generally makes it quite impossible to ensure driving it before us, prevent the formation of any plan from which rapidly decisive results can be hoped. Strategy, in the ordinary sense of the word, fails us. An advance into the enemy's country does not necessarily mean the possession of the country in rear of the army. To turn his flank or threaten his rear may be attempted, but for these the foe does not care. His flanks are but the extremities of his line, his rear is merely that portion of his country towards which his face does not happen to be turned. In fact we have to deal as it were with one of those brainless, back-boneless animals, which may be *destroyed*, but can scarcely be *killed*. Consider the position of Lord Chelmsford as he advanced upon Ulundi. Day after day passed and no considerable body of the enemy was seen; the army moved on, but the country it passed over, except perhaps in the immediate neighbourhood of the fortified posts established on the line of communications, at once relapsed into the enemy's power. It was true that considerable damage was done to the enemy's kraals and crops along the line of advance, but the sum total of the injury inflicted was far from sufficient to produce a satisfactory conclusion to the war. To have systematically destroyed the country would have required much time and more money. Even the destruction of the king's kraals at Ulundi would have had but a small effect upon the nation. And yet till the Umvaloosi was reached, the betting in the army was that there would be no battle there, and without a battle there would be no effective situation on which to ring down the curtain. But luckily, if strategy fails to ensure a successful conclusion to any series of operations that may have to be undertaken, moral force comes into play to supply the necessary 'something' which may lend an aim to our movements. The one circumstance which, as a rule, can alone lead to the commencement of a war such as we are now discussing, is the existence of a combative and aggressive spirit on the part of the natives. This spirit, as experience has always shown, will lead them, sooner or later, to attack any force that advances into the country. Push a column into the enemy's territory, and if necessary annoy him by burning his huts, destroying his kraals, and carrying off his cattle, and a battle is almost sure to result. Arogee, Amoaful, Ulundi, are all examples of this tendency, and the failure to bring on a combat would go far to condemn the war as unnecessary.

Granting then, that, notwithstanding the enemy's *power* to baffle us by refusing an encounter, a struggle may be counted on, and half the battle is already gained. Presumably our preparations have been made so as to insure success, and with victory in the field the task will in many cases be finished, and in all will be partially accomplished.

At the outset, then, we are met with one great difference between civilised and savage warfare. In the former the first great requisite is to know the whereabouts of the enemy's army; to find it, attack it, and beat it. In the latter this army has frequently—nay, usually—no fixed whereabouts, and we advance to let it meet us, acting ourselves offensively or defensively in the actual battle according to circumstances.

But, again, there is this further difference. We cannot always insure that the advancing army shall cover the territory in its rear. We cannot tell where the enemy will collect his men, in front of us, in rear, or on a flank. Almost entirely independent of lines of communication his movements are freed from the restraints of civilised armies. Were it not for the moral influence of which I have already spoken, there is nothing to prevent him from leaving the army to advance while he falls upon the settlements in rear. That experience shows that this will seldom be done may be true, but the possibility of it always exists.* Farther on I shall have some remarks to offer on the defence of the frontier of the colony from which our operations start (I am taking the usual case). Here I will presume that the proper precautions have been taken. Still we must remember that it is frequently impossible to protect our line of communications from attack, and that our advance will not clear the country as we go. Are we, then, to be content with merely pushing forward a body of troops with the intention of challenging the enemy to fight us where and when he will? Undoubtedly not. Some other and more definite object must be held in view, in the execution of which we may hope to meet and destroy the enemy's army.

If we turn to the history of previous wars we shall find that the objective has usually been one of two things, either the king's residence, or some stronghold which has been prepared by the enemy as the final place of resistance. Thus Coomassie and Ulundi are types of the former, Sekokuni's town of the latter, while Magdala was a combination of the two. The value of points like these depends chiefly upon moral causes. The kings of savage tribes are the equivalent of the able man of the Teutonic tribes from whom our modern monarchies have arisen. Surrounded with even more than the usual

* The following extract from Col. Malleson's *History of the Indian Mutiny*, Vol II., p. 124, describes a somewhat analogous state of affairs, as occurring along the great trunk road from Calcutta to Allahabad. 'On the right the remnants of the Dánápúr garrison, of the 5th Irregular Cavalry, and subsequently the mutinous portion of the 32nd Native Infantry, uniting themselves with the bands of the Kúnwar Singh, threatened the districts in the neighbourhood, and spread consternation amongst the local authorities. These mutinous bands constituted the great difficulty of Sir Colin Campbell. Not that they were sufficiently formidable to check a British force. Could they have been found collected, a few companies of Europeans would have annihilated them. But spreading over a vast tract of country, they harassed every district, and threatened every post.'

divinity that doth hedge a king, these chiefs generally exercise an absolute sway over the lives, limbs, and property of their subjects. But to exact the implicit obedience which every native potentate regards as his just due, the king must inspire awe, physical or superstitious, in the hearts of his subjects. Always regarded as the most powerful being in that part of the earth, if not in the whole world, frequently looked upon as possessing divine attributes, the native sovereign is secure so long as he can maintain himself against his outer enemies. Should he, however, fail in war, his potency vanishes at once. The man who can protect his subjects from the attacks of his enemies may be permitted some little licence in punishing those who have offended him; but the chief whose very palace is invaded and burnt, who cannot save his tribe from the destroying hand of a foreign foe, cannot expect to exercise the royal privileges of murder and torture. It is for this reason that the capture and destruction of the king's residence has usually sufficed at least to alter the character of the war. Some few devoted followers may yet remain firm in their allegiance to their rightful lord, but the bulk of the nation will at once transfer to the invader that fear upon which their obedience to their king was based. The actual damage done to the nation by the destruction of the king's palace may be small, but the moral effect cannot but be great.

Similarly, the capture of a stronghold prepared beforehand with a view to the final struggle, will usually be well worth the effort made to take it. Fortified, perhaps, to the best of their ability, chosen on account of its natural strength, and regarded as the final chance of safety, after being worsted in the open, its loss must awaken the natives to a sense of the hopelessness of continuing the struggle.

Here, then, in the absence of any more definite objective, we have the foundation for the plan of campaign. First, we intend to advance well into the interior of the enemy's country, prepared to give or accept battle wherever we may find the enemy. Secondly, we direct our march upon the king's residence, or the chief stronghold of the nation, or both, hoping to engage the enemy while on the march to either. To these may be added, thirdly, to do as much material mischief as possible to the enemy during the advance by destroying his huts and crops, and seizing his cattle.

Special objectives may frequently be found which may prove to be of greater importance than those first discussed. Sometimes, also, the conditions under which we meet the enemy may lead to a system of manœuvring more nearly like what we are accustomed to in European warfare. Thus at the commencement of the Ashanti war the first objective held in view was to clear the Colony of the enemy's presence. It is necessary here to draw a distinction between engaging an enemy in his own country and out of it. In the former case, as I have already pointed out, he has practically no lines of communication. When, however, he has quitted his own country in order to invade one of our colonies, he is to a certain extent dependent on some road by means of which his supplies of ammunition, and it may be food also (though frequently he will subsist himself on the country in which he is), are brought up. By threatening to cut him off from his home his hold upon the invaded territory will generally be lessened. Sooner or later he will fall back altogether, or at least collect to endeavour to drive back the column threatening his country. In such a case, then, some elementary form of strategy becomes possible.

Again, the nature of the country may sometimes assist us in clearing it as we advance, and thus enable us to drive the enemy together to some place where we may crush him *en masse*. Thus, in Ashanti, the bush was frequently too thick even for the natives to traverse it in any number, save along certain definite paths. He was thus tied down to certain lines of advance, his whereabouts could be determined, and he could be brought to battle or made to retire.

In preparing for a campaign against a savage nation, it is very necessary to learn as much as possible of the habits of the tribe. In some cases the absence of all power of combination will lead to a series of petty affairs, each decisive so far as it goes, but no one of them leading to the submission of the whole nation. Such was the case in New Zealand, where one post after another had to be captured, but where battles on a large scale did not take place. In other instances we find the nation acting as one army, permanently under arms. Ashanti may be taken as an example of this, where the force the enemy put in the field was very considerable, and was kept together for a prolonged period. In this case the enemy's army must depend upon some line of communication. It must have some magazine or magazines from which it draws its supplies, and a definite plan of operation becomes possible. A system such as that of the Zulus is far more difficult to deal with. Cetewayo had built up a large, well-disciplined, and highly-organised force. His army was not accustomed, however, to keep together for any length of time, and, indeed, his commissariat arrangements enforced a system of dispersal for subsistence which differed only in degree from that of the French army in the Peninsula. Orders having been issued for the army to assemble at some assigned spot, usually the king's kraal, on a given day, some 20,000 to 30,000 men poured in upon it from all sides at the appointed time. These men brought with them from their kraals their arms and ammunition, and sufficient supplies to last them for a few days. A day or two sufficed to brigade and organise the force and go through the customary religious rites. Then the army would start upon its expedition, with some definite task assigned to it; to attack some given point, or fight a battle with a given column. The purpose accomplished, successfully or not, the army would disband itself, each man returning to his own kraal till called up again for some new expedition. Here, then, we had in perfection the system whereby a large army became independent of any base or line of communication. It would have been impossible to have made our movements depend upon those of a force which only existed on the day of battle, and which could choose its own time and place for the struggle. It remained only, therefore, to fall back upon those general objectives I have described above. Nor did these fail in accomplishing their object. Devastating a considerable tract of country as we advanced we brought the rigour of war home to a large portion of the nation. The slow and steady advance of the column must have shaken their faith in the strength of their 'able man,' he to whom they had yielded such unlimited powers that he might protect them from all foes. Then came the trial of strength in the open, where courage and numbers rushed to their inevitable fate, and were destroyed by the discipline and weapons of civilisation. This brought home to their minds that the ravaging which one portion of their country had already undergone might at any moment overtake the remainder. Finally the destruction of their king's kraal proved how little terror their dread monarch had for the white invader. In the earlier phases of the war the Zulus had suffered at least as heavily, in more than one engagement, as they did in the final battle at Ulundi, but the moral effect of the advance, the devastation, and the burning of the king's kraal were wanting. In consequence, Ginginhlovo and Kambula, great victories as they were, could not end the war. On the morrow of Ulundi, however, small parties traversed the country without fear. That battle finished the struggle.

Before quitting this branch of the subject, there are two points to which I wish to draw attention. It may be said that I have wasted too much space in dilating on the moral effect of destroying the king's residence. That it stands to reason that to do so must have much influence on the campaign. This may be so, but I know it was not the commonly-received opinion before the battle of Ulundi. The common argument then was that the king's kraal was a mere collection of huts without value to the nation. That to burn it would merely result in his migration to some new spot, where a few weeks' labour would result in the rise of a new kraal, perhaps in some more inaccessible place; that the Zulus, if they did not attack us to prevent our burning their own homes, would not do so to save Ulundi. So strong was this opinion that Archibald Forbes (the newspaper correspondent) made a bet of a considerable amount, on the very day we arrived at the Umvaloosi, that no battle would occur. It is not, therefore, without some reason that I have enlarged upon the importance of this matter.

Another point to which I wish to draw attention, is the justice of doing as much material mischief as possible to the enemy by destroying his crops and burning his huts. Major-General Sir James Alexander, K.C.B., who has had much experience of this style of warfare, says in his *Bush Fighting*, 'The stockade was pulled down and burnt, and several "aharrés" (huts) near it; and some cultivation was destroyed. This is unfortunately the custom of war. I had seen it done in Africa and in Turkey. I would not sanction it now, knowing the terrible distress occasioned to helpless women and children, besides shelter and food gone, and perhaps before cold and wet. Few things rankle in the hearts of cultivators more than the loss of their crops, and render men more savage and *less inclined to peace* than fields laid waste; but it is the custom of war to do so. "Fire and sword!" the word.' Now, undoubtedly, wanton and unnecessary cruelty is as wrong in war as in peace, and should never be resorted to under any circumstances. Further, it is a criminal blunder 'to render men less inclined for peace,' and hence when there is a chance of bringing our foes to reason by kind treatment, it is wise, as well as right, to act with moderation. But it should never be forgotten that war is, and must be, to a greater or less extent, brutal. If the war be a just one—and the presumption is that our country would not wittingly engage in an unjust one—it is but right to do the best we can for our own cause, to shorten the war by all means in our power, and by inflicting suffering on the enemy bring things rapidly to a conclusion. Unfortunately the savage on the war path can seldom be influenced by mild measures. To spare his home and crops seems to him a sign of weakness, and generally acts as an inducement to hold out longer against our efforts. To burn his huts and destroy his crops is to bring the rigour of war home to him, to reduce his means of carrying it on, and to produce a moral effect, which will sooner or later make him sue for peace. In most savage countries the amount of cultivation exceeds but little the necessities of the nation. Every field destroyed produces a direct effect upon its strength, and by producing want tends to bring it to its senses.

At the commencement of the Zulu war, at a dinner at head-quarters, an officer was arguing with Lord Chelmsford that by waiting for the dry season many of the transport difficulties, already felt, would disappear. The answer was, 'I must have those mealies.' The mealies, on which the Zulus chiefly depend for food, were then nearly ripe. In two more months the crops would have been cut, and the next year's supply of food would have been stored. The General's object was to destroy as much as possible of the crop, and thus prevent that easy system of commissariat which enabled the Zulus to collect large armies at will. Humanitarian principles sound well on paper; in practice they must give way before the realities of war.

Having thus in some measure indicated the objects to be held in view, it remains to say a few words on the means of carrying them into execution. The first question which will strike every organiser of an expedition must be, Shall I advance in one column, or in two, or many? In Abyssinia, one column was used; in Ashanti, there was one main column, aided by two auxiliary ones; in New Zealand, there were many; in Zululand, there were at first five, and subsequently two. What then guided the Generals concerned in their choice of the manner of effecting the advance?

In the first place, it is obvious that if the absence, or comparative unimportance, of the enemy's line of communication destroy the chance of using strategical combinations (in the higher sense of the word) against the enemy, two or more columns cannot be used for such a purpose. Indeed, it will be usually found that each column has a definite and separate task before it, that during the advance it cannot hope to obtain any support from its neighbours, and that it, by itself, must be prepared to sustain the heaviest attacks the enemy can make. But if each column has to be so strong as this, why, it may be asked, cannot one column alone effect the object of the war? In answer to this, let us examine the original plan of campaign in Zululand, by which five columns were to advance simultaneously, from widely distant points, upon Ulundi. In the first place, it was evident that, with two exceptions, each of these columns could be attacked by the whole force of the enemy, without receiving any support from the neighbouring columns. Of these, Nos. 1, 3, and 4 were the chief, and were of nearly similar strength; No. 2 was subsidiary, and could hardly be regarded as more than a covering body for the middle of the Natal frontier; and No. 5 was to join No. 4 very early in the advance. The strength of each column (erroneously as it turned out) was supposed to be sufficient to resist any attack that might be brought to bear upon it. They were to advance, burning the kraals and destroying the crops, and thus clearing the country, as far as could be, to Ulundi. The country included between any two lines of advance could only partially be cleared, of course, and but for the moral effect caused by the invasion, there was nothing to prevent the whole Zulu army maintaining itself in rear of our columns near the Natal border, eluding our forces as long as it liked. But it was felt that moral effect must have some weight even with a nation like the Zulus, and it was believed that the head of one or more of the columns would be sure to attract the enemy's attention. In this manner it was hoped that greater protection would be afforded to the colony than would be the case were one column only to advance. By increasing the area of country occupied and devastated by our men, it was also thought that the rigour of war would the sooner be brought home to the natives, and a speedier conclusion to the war would be brought about. In the result, it would appear that these ideas were just, but the plan failed because the columns were not strong enough to effect their purpose. The 2nd and 3rd columns, defeated and partially annihilated at Isandhlwana, had to fall back. The 1st column, surrounded by large numbers of the enemy, remained fixed at the spot where it heard the news of the disaster that had befallen the 3rd. The 4th column was not allowed to advance, lest a similar fate should be its lot. But the colony was *not* invaded.

It is evident, therefore, that whatever considerations may induce us to use more than one line of advance, such a method of procedure should only be employed when sufficient men are available to render each column strong enough for independent action; and further, that no stress should be laid upon the *strategical* importance of the movement.

I think we have somewhat cleared the ground for our advance. We have recognised the futility of deep-laid strategical schemes; but we have admitted the comparative certainty of meeting the enemy in his own country if we advance. The chief objects to be held in view have been pointed out, and now it remains to organise columns and prepare for the defence of the frontier before starting. The latter of these will be first taken.

Defence of the Border.

Few questions can be more perplexing to a General than that of the defence of the border of a colony which is contiguous to the future theatre of war. To take Natal once more as an instance, how many men would it have required to render the Colony safe from invasion? First it must be remembered that natives usually can move nearly twice as quick as our Infantry, and that it is seldom possible to discover their whereabouts or intentions until some enterprise on their part be actually commenced. In endeavouring to guard a frontier of 150 miles from the possible attack of 20,000 to 30,000 savages, two chief plans present themselves. A force capable of defeating such an enemy may be kept at some central point, ready to move on news arriving of an actual invasion, in which case it will always be liable to find itself eluded by the enemy; or detachments may be placed in fortified positions along the line, each capable of resisting small parties of the enemy, but none able to defeat his main army in the open. In either case it is evident that it must lie in the enemy's power, *if he neglect all risk his own home may be running*, to effect an invasion in comparative safety. The farmers and inhabitants of the open country cannot hope to escape all risk of harrying, unless a moral pressure can be brought to bear upon the foe which will prevent his attempting a counter-invasion. Lord Chelmsford was much blamed by many people for concentrating his strength at the two extremities of his line, and leaving the centre unguarded. But was he justly so blamed? He could answer that it was impossible, without using every man he had, aye and more than every man he had, to protect the border from Zulu forays should they wish to attempt them. His one chance of preventing any mischief from happening was to occupy the enemy's attention at home. To employ any large portion of the British army in watching the frontier defensively was to throw away the chance of ending the war quickly, and to attempt a task which was scarcely possible. It was an absolute necessity, if the war was to be brought to an end, to move nearly every available man into the enemy's country. Political reasons,* which, having nothing to do with the subject of this essay, I need not mention, rendered necessary a concentration of forces on the N.W. border of Zululand, and consequently one column of troops (and, as it turned out, the chief one) moved in from this side. The proximity of the sea, and the comparatively superior nature of the road along the coast to those between it and the northern line of advance, decided the route taken by General Crealock. To have moved this latter column in by a central road would have certainly added to the apparent safety of the colony; but I fail to see how it would have done so practically. The principle that it was impossible to debar the enemy from invading the colony if he wished to do so,

* At the time this essay was written the Boer revolt, though already threatening, had not yet broken out. I need scarcely say that it was the danger of an insurrection in the Transvaal to which allusion is made in the text.

save by threatening his own home, had to be accepted. Once accepted, the distribution of the invading columns had but little to do, directly, with the defence of Natal. Certain precautions, however, could be, and were taken. If it were impossible to protect the widely scattered farms from danger, it was necessary to ensure the safety of the farmers and their families. To do this there was in each district a laager, or fortified camp, into which they could retreat on the approach of danger, while to give them due warning the whole border was watched by native lines. Beyond organising the colonists for their own defence, appointing Commandants for each district, and assigning the laager to which each man should repair in case of invasion, nothing could be done save trusting to the effect of the advance of the invading columns. To show how small is the effect of fortified posts along a border I may mention that, while a force of 800 men were in camp at Rorke's Drift, the Zulus crossed within six miles of that point and attacked some kraals of loyal natives, retreating, after accomplishing their object, without loss.

But though it is hopeless to endeavour to obtain absolute immunity for the border farms from raiding and pillaging, it would be inviting the enemy to attempt reprisals of this nature if no armed parties were available to render his movements insecure. For this purpose infantry can be but of little use, and mounted men, dragoons for preference, should be stationed in as strong parties as may be possible at distances not greater than 20 miles apart along the frontier. They may not always succeed in catching the enemy before his task is accomplished, but one or two successful attacks upon him will soon instil a feeling of respect for the defensive powers of the colony. They should at least prevent the enemy from carrying off much plunder, and should he embarrass himself with cattle and other impedimenta, they ought to be almost certain to come up with him before he can make good his retreat.

An actual invasion in force is hardly to be dreaded while the enemy's territory is being invaded. Should one be attempted it must be remembered that even a savage army of any size acting in a foreign country must have a line of communications by which supplies are brought up. Close in upon this line and the army must dissolve: it may escape, and it probably will, but the invasion will be brought to an end.

Transport.

No matter weighs more heavily on a General in charge of an expeditionary force than the arrangement of his transport. In general he has no regular organisation upon which to fall back. Everything has to be created anew, and out of the materials on the spot. It may be laid down as a maxim of almost universal application that it is better to use the system of transport employed by the inhabitants, and which, presumably, is that which has been found best fitted for the conditions of the country, than to import foreign waggons and foreign animals. Thus, in New Zealand we used the common two-wheeled carts of the country. In Abyssinia we employed pack animals. In Ashanti we were forced to employ human carriers. In Perak boats did the greater part of the work. In South Africa the bullock waggon was the chief means of transport employed. Now each of these did good service in their own country, but I doubt whether any one of them would have been bettered by endeavouring to employ one of the other methods. In dealing with waggons and animals it must be remembered that the *personnel* of the trains will be supplied in a great measure by the natives of the country, and it will not be easy to train them to systems of which they are ignorant.

As an example of what certainly seemed to me a mistaken desire to introduce the system of one country into another, I may adduce the attempt to employ human carriers in Natal and Zululand. Near the end of the war, when Sir Garnet Wolseley and his Ashanti staff arrived, it was determined to endeavour to organise corps of carriers in a manner similar to that employed on the West Coast. The main reason for making the attempt was economy, the bullock transport having risen so enormously in price. According to the calculations I made at the time, and in which I still believe, this economy was purely imaginary. Nor did these carriers possess any peculiar advantages to make up for certain very grave disadvantages. It was supposed that when the roads had got into a bad state after the commencement of the rainy season, that these human carriers would have been able to continue their work almost as efficiently as in the dry season. Well, I was at St. Paul's when the first heavy downpour of the season occurred. The rivers rose, and for some days no carriers came in. After a time, however, they began to arrive (and bullock-waggons came in at the same time), but in nearly every case it was found that the packages carried by the men had been so damaged by rain as to be perfectly useless. I sat on a board which had to condemn large quantities of stores ruined in this manner, and I have no hesitation in affirming that under a waggon cover they would have been perfectly safe.

Beyond urging, then, that the habitual transport of the country should be used, it would be hopeless to lay down any laws in the choice of the means to be employed. As each arises, the peculiar conditions presented by it must be taken into consideration, and a decision arrived at accordingly.

Presuming, therefore, that the choice has been made, it remains to consider some of the peculiar circumstances which usually modify the system under which it is worked. On reading any work on tactics, one point in the arrangements advocated for the transport and commissariat, strikes one at once. The ground in rear of the army is supposed to be covered by it, and to be safe from all but small marauding parties of the enemy. In our native wars the very reverse is the case. The ground first traversed by the column is frequently quite as dangerous as that in front of it. Practically there are no lines of communications, and the army must be self-supporting. A similar state of things sometimes occurs in civilised warfare, as, for instance, in Napoleon's retreat from Moscow, or Sherman's march to the sea; but it is very rare. As a first result it is evident that the army must carry with it all that may be required for its maintenance and efficiency during its absence from its base. No daily arrivals of provisions, clothing, or ammunition can be expected from the rear. In the waggons, or other means of transport, must be all that is required. But not only must all the transport train accompany the army, but more must be carried in it than would be the case in civilised countries. Sherman's army foraged as it went, and depended largely on the country through which it advanced. Napoleon's army marching on Moscow fed to a great extent upon the country, but having exhausted this resource it suffered terribly from want during the retreat. Had France produced as little as Abyssinia the German army would have required a transport train at least four times as great as that which accompanied it. In Zululand, beyond grass for the oxen and a limited amount of mealies for the horses and mules, nothing could be obtained from the country. Everything had to be carried; the army had to be absolutely self-supporting. And so it must be in all our native wars. In consequence of this it is evident that an army taking the field against a savage foe must be accompanied by a far larger train than would be the case in civilised warfare. Take, for instance, the combined column that marched to Ulundi. It consisted of about 6,000 white men and 3,000 natives all told, or about the equivalent of an English Division. It carried with it 700 waggons, mostly bullock waggons, capable of carrying 4,000lbs. each. In this manner stores for two months were carried forward, and for that space of time the army was absolutely independent of any line of communications, or any base. But conceive the column of waggons which this enormous transport formed, extending in single file for a distance of

15 miles without intervals, and then remember that a force of 10,000 men was all that was there to guard it—not more than 600 men per mile. It is true that by marching four, six, and even eight abreast the line could be, and generally was, very much reduced in length; but on the other hand it was impossible to avoid intervals. As a matter of fact, the whole army could form but little more than a guard for its own baggage.

It is evident, therefore, how vitally important it is to cut down the number of things to be carried forward to a minimum. As our savage foes improve in organisation and arms, and assuredly they are improving and will improve, it will become more and more necessary to fight as light as possible. Many luxuries, which were regarded as necessities in times past, will have to be given up for the future. As much as possible must be carried by the soldier, as little as possible by the waggons.

During the Zulu war it was a very uncommon thing to see a man carrying his own valise, and judging from the number of men who had to be carried in the waggons from sore feet and other causes produced by marching, perhaps it was well that it was so. But it must be remembered that a considerable increase of strain was thrown upon the transport in consequence, and that some 50 waggons were required for this purpose alone, the equivalent of 100 of our G. S. waggons. It might be as well, therefore, to consider whether, if the men are not to carry their own valises, some more economical method of packing might not be advised than one which certainly gives a maximum of weight for a minimum result.

But, at the best, a train out of all proportion to the number of men supplied by it must be taken into the field if the army has to depend upon it for any length of time. To avoid this a system of advanced depôts must be formed, each of which in turn becomes the base of the army. Thus, before the army marched to Ulundi, the whole powers of the commissariat were employed in accumulating some four months' supply at the advanced bases of Landtmann's Drift and Conference Hill. When this had been accomplished, almost the whole of the waggons were taken off the Durban-Maritzburg-Dundee road, and loaded up from these advanced bases ready to accompany the army into the field. An advance of 40 miles was then made, when the stores were placed in a new advanced depôt at Fort Newdigate, the waggons returning to Landtmann's Drift for a fresh supply. To do this in safety the whole of the flying column (practically half the available army) was sent back with the convoy, the remaining half occupying the ten days that elapsed before a new advance could be made in opening up the country, destroying the kraals and crops that lay within reach, and generally endeavouring to prove to the Zulus that the hour of retribution had arrived. On the return of the waggons the column was enabled to resume its march with its stores replenished to the amount at which they started, while an advanced depôt had been formed on which the army could fall back for fresh supplies, if necessary, without evacuating the enemy's country.

Had it been needed, this advanced depôt system might have been extended as much as required, fresh advanced depôts being formed farther and farther inland. The theoretical limit of the operation would be reached when the time taken in making the return journey was so long that the army would consume, during the absence of the train, as much as it could bring to the front.

As a matter of fact, it could hardly ever occur that such a system should become necessary up to its extreme limit. Much as has already been urged as to the impossibility of clearing the country as the army advances, it is evident that the longer the operations last, and the more damage is done to the country near the line of communications, the safer will these become. Sooner or later convoys under comparatively small escorts will be able to move backwards and forwards, and from that time the commissariat arrangements will approach more nearly those usual in a European war.

Small convoys with small escorts must, however, at all times be sent along the line of advance. Wounded and sick men must be sent to the rear, the post must move backwards and forwards, and orderlies and messengers will have to keep up the chain of connection with the army. To allow of this being done, it is necessary to maintain a series of fortified posts where rations may be issued, horses changed, and a safe night's rest obtained. These posts may or may not be garrisoned with a force capable of undertaking expeditions into the neighbouring country, but they *must* be strong enough to resist all attacks of the enemy, and they should have enough mounted men belonging to them to insure the country around, and more especially the road between the next forts and them, being properly scouted. In ordinary cases the moral effect of these forts will keep the surrounding country quiet, except when the enemy has sent a large force into the neighbourhood for any purpose. When this is the case the scouts should usually be able to discover its arrival, and the necessary precautions may be taken. Perhaps it will be requisite to delay the passage of all small parties for a few days, but the danger will generally pass away before long, either by the dissipation of the army, or by its attacking one of the posts fruitlessly. If it do not attempt anything of this nature, and yet remain in the neighbourhood, of course reinforcements must be obtained, and an attack be made upon it. Further on I shall have more to say on the subject of these posts along the line of communications; here I only mention them in connection with the system of transport.

ORDER OF MARCH.

Having now prepared everything for the advance into the enemy's country, it is necessary to organise the order of march, so that all danger from a sudden attack of the enemy upon the convoy may be avoided. As in all other operations of war, no definite rules can be laid down for this which will be of universal application. At the same time I think the conditions under which Lord Chelmsford's columns advanced into Zululand are not unlike those which will usually be presented in wars such as we are now considering. A vast mass of transport had to advance into an enemy's country, the features of which were but little known. The enemy was numerous and plucky, and possessed of all the advantages afforded by rapid locomotion and freedom from the restraints of a base and line of communications. His movements and whereabouts were unknown, and the column had to move in a formation which would afford a ready means of defence in case of sudden attack. I was myself attached to Sir Evelyn Wood's flying column, and I think I cannot do better than describe the arrangements made by him, at least as far as I could understand them.

The flying column consisted of three battalions of Infantry, two batteries of Artillery, one company of Royal Engineers, about 500 mounted troops (mounted Infantry and Colonial corps), and some native irregulars. Excluding the natives this gave a force of about 3,000 men of all ranks. The transport consisted of 250 bullock waggons, and about 100 other vehicles of sorts. Each waggon occupied about 25 yards of road, the other carriages about 10 yards on an average, consequently the entire column took 7,250 yards when extended in single file without intervals. As a rule it marched with from four to eight waggons abreast, and in good ground (allowing for the unavoidable intervals) the length of the column was about 1½ mile. At times, however, it became almost indefinitely lengthened out, the last waggon on some occasions not getting into camp for many hours after the first.

It must be remembered that it was deemed possible that the convoy might be attacked from any direction with but little warning, and at the same time that it was necessary to be prepared to defend it without too great dissemination of the small force composing the column. For this purpose the three battalions marched one at the head of the column, one in the centre, and one at the rear. Each regiment was kept together, only sufficient men being detached among the waggons to do the necessary police duties, and to furnish advanced and rear guards and flanking parties. The convoy was divided into three sections, each guarded by one battalion, and in each of which was the baggage of that battalion. In case of an alarm, the head of each section was to halt, wherever it might happen to be (care being taken, of course, not to halt, if possible, in a disadvantageous position). The tail of the section was then drawn in as rapidly as possible, and the waggons parked, so as to enclose a space of ground into which the bullocks and mules could be driven for safety. 'Laager' being thus formed, each battalion prepared to defend its own section of the train.

When the column had been marching in single file, the laagers, formed in this manner, were too far apart to afford mutual support, but each was considered strong enough for independent defence. Besides, the enemy could not possibly surround all three at once, and to have attempted to do so to one or two only would have been to expose himself to an attack in rear. When, as was usually the case, the waggons marched four or more abreast, the laagers, when formed, were within supporting distance of each other.

It was found by experiment that under favourable conditions, that is in open country and with the column closed up, this formation could be completed in half an hour. There were occasions, however, when it would have taken many hours to complete it, as in the march to St. Paul's, and in this case an attack from the enemy might have proved serious. But even so the arrangement was perhaps the best that could be devised. A portion at least of the laagers would have been completed before the enemy could have closed, and that portion would have been of some service in aiding our men in beating off the enemy. The safety of the bullocks would, however, have been endangered, and it is as well perhaps that the Zulus never displayed sufficient intelligence to take advantage of our difficulties. Thus, for instance, on our arrival at Jackal's ridge the enemy was reported in force in front of us. Orders were issued to form laager, but it was hours before the last waggons were in position.

In one case, the action of Inyezane, a convoy on the line of march, in a place where laagering was impossible, was attacked. The head of the column was enveloped, and the horns, characteristic of Zulu tactics, were thrown out in order to envelop our men. In this, however, the Zulus were disappointed. The length of the convoy being too great the horns could not surround it, and they themselves were taken in flank and rolled up. Here then we have a case of the habitual tactics of the enemy failing because they were not fitted to meet the circumstances of the case. Had the Zulus, however, employed the tactics of Ulundi, combined with the dash of Isandhlwana, it is difficult to see how the convoy could have been protected. The men composing the escort might have held their own, and in the long run have driven the enemy away, but a large number of the oxen might easily have fallen into the hands of the enemy, and the transport of the column have suffered great loss.

In bush countries the line of waggons must lengthen out, and it can seldom be possible to move more than two or three waggons abreast. This of itself adds greatly to the danger of an attack from the enemy, but this danger is still further increased from the difficulty of parking or laagering the waggons on the approach of danger. But even in open country the former of these two sources of danger is frequently present. Narrow places (fords, cuttings, necks of land, or other defiles) may have to be passed where but one waggon at a time can get through. In such a case the opening out of the column is almost inconceivable. I remember one place on the march to St. Paul's, where the convoy had to descend a steep hill, where drag ropes had to be used. At the bottom of this was a stream which had to be crossed by a ford at a sharp angle, while on the far side was a steep pull up by a road cut into the side of the hill. The unwieldy bullock-waggons were not easy to manœuvre through these difficulties, and on the average not 30 yards, but 300 yards, separated them by the time the summit of the hill on the far bank was reached. Now it is evident that if each waggon, after crossing, were to proceed on its way at once, the length of the column would have been indefinitely increased, and all attempts to systematic defence would have been fruitless. To diminish the risk as far as possible, the leading waggons were halted on reaching the top of the hill beyond the ford, and laager was formed there as team after team arrived. The bullocks were turned out to graze immediately, as it was necessary to take advantage of every possible opportunity of feeding them. When the leading section of waggons had all formed up, the second laager was commenced near it in a similar manner. The leading section did not move off at once, however, but waited till its last arrived oxen had had a graze, and then 'inspanning' it proceeded on its way, leaving the second section laagered, and the third section crossing the ford. Of course such an operation took time, and it is not to be wondered at that, though the day's march was only seven miles, and the first waggon started at 5 A.M., the last waggon did not reach the new camping ground till midnight.

With precautions such as these, it was to be hoped that any attack the enemy might make would be received in that formation best fitted to resist it. But to insure this it was necessary to have timely warning of the adversary's approach, and for this purpose the ordinary precautions of Cavalry foreposts, and Infantry advanced and rear-guards, were taken. The only special precaution requisite was extra care in scouting to the flanks and in rear, from which directions the attack might be expected with as much likelihood as from the front.

Reconnaissance.

Before the column can start, it is above all things necessary that some knowledge of the country about to be traversed should be obtained. During peace time, the Intelligence Department collects such facts concerning the countries in which military operations may have to be undertaken, as it is found possible to obtain. Traders' and explorers' accounts are collected, and the results compared and tabulated. In this manner, the Department is usually in a position to publish much useful information at the commencement of a campaign, while maps can also be produced which, though they may require much subsequent correction, convey at least some idea of the country. But let me here give one word of caution about these maps. Although the general lie of the rivers and towns may be shown, errors of considerable magnitude, even to the extent of two or three days' march, will frequently exist. In the Zulu maps published before the capture of Ulundi, the king's kraal was placed some twenty miles from its true position, several important rivers were omitted altogether, and others were shown as running direct to the sea, which really flowed into each other some distance from it. It would therefore be manifestly unsafe to trust to these maps without constant correction from actual observation. Another point, which is perhaps worthy of remark, is that ambitious-looking maps, with hill-shading, are often less useful than simpler ones, in which this is omitted. Hill-shading, unless fairly accurate, is misleading; and even if its presence be ignored, it tends to make the map confused, and to render its correction more difficult. The hill-shading in the Zulu map was inaccurate throughout. On the Natal side of the border it was worst, for there it pretended to give most detail, the whole of which was purely imaginary. On the Zulu side it was better, for there, as a rule, the mountain masses were merely indicated, and so long as one remembered in reading the map that a blank space did not necessarily mean flat, but rather unknown country, little harm was done.

In savage warfare, the object of reconnaissances is usually more to find the road than to discover the position of the enemy—to seek out camping grounds, passes over mountains, and fords over rivers, these are the chief points to be attended to; to which may be added, noting the resources of the country, the state of the crops, and so forth. The reconnaissances may be divided into two classes, but the precautions necessary for the proper conduct of each are the same, except that in those of the second class there is no question of camping out, and the parties employed may be much smaller.

(*a*) Reconnaissances on a large scale, undertaken by considerable bodies of men (usually mounted), who proceed some distance into the enemy's country, remaining out for one or more nights.

(*b*) Reconnaissances on a small scale, where small parties go in as far as they can, returning the same day.

The reconnaissances of Lieut.-Colonel Buller, V.C., in the early days of May, may be taken as an example of the former; while of the latter there were almost daily instances during the fortnight that preceded the final advance. The following rules may be useful for these operations:

(1) Go one way and return by another. By this means two roads may be explored during one reconnaissance, and the chance of being cut off during the return journey is much diminished. Thus a reconnaissance which left Llandtmann's Drift, May 17th, crossed the Buffalo at Robson's Drift, and the Blood River at a point two miles above its confluence with the former. Proceeding then close under the north spurs of the Nkongane Hill it reached a point near the head of the Bashee Valley. Returning, it kept in a line north of the former, recrossed the Blood River at a point ten miles higher up, and striking the Conference Hill road crossed the Buffalo at Landtmann's Drift, having traversed nearly fifty miles during the day.

(2) If obliged to bivouac in the enemy's country, cook the evening meal, and make preparations as if to sleep in a given place, but an hour or so after dark move one or two miles farther off. This precaution may often save a surprise, particularly if a good look-out be kept in the direction of the first halting place.

(3) If not out for more than one or two days, keep the horses saddled during the night.

(4) Strike no lights, and keep silence after moving from the first halting place.

(5) Have one or two mounted men circling round the bivouac all night, at about a mile radius.

(6) Remember that a reconnaissance is not intended to fight save in self-defence.

(7) Do not halt in enclosed ground. Remember the fate of the Prince Imperial.

(8) Do not trust to the memory, but take notes as you go on.

The task of making reconnaissances now belongs to the Quartermaster-General's Department, but it will be frequently found that Officers of Engineers are told off to assist in this duty. At all times it would be well if an Officer of Royal Engineers accompanied each reconnaissance, if only for technical purposes. He should note the characteristics of the country with a view to determine beforehand the nature of the work the Sappers will have to perform, and he should also look out for favourable sites for the construction of fortified posts.

Camps.

The sites selected for the camps at the end of each day's march must, in great measure, depend upon the proximity of wood and water; but in every case the camp when pitched must be defensible. The uncertainty of the enemy's movements, which is an almost unvarying feature of savage warfare, renders it necessary to be always prepared for an attack. At the commencement of the Zulu war a little book of regulations for the guidance of the field force was published by command. In this book one paragraph ordered that the camp should be fortified each night. As a matter of fact we know that in the first advance this precaution was not taken, a fact which has frequently been severely commented on. Certainly after Isandhlwana a great change was apparent, and laagers were formed at every halting place. But yet I do not think it follows that *fortified* camps will always be the rule. The camps must be 'defensible,' but it does not follow that our men must always fight behind walls.

If by fortifying the camp we mean that earth-works are to be thrown up, the task will usually be found impossible during a continuous advance; shelter trenches may be made, but time and strength will scarcely admit of more. Now, a shelter trench undoubtedly affords great protection from the deadly effects of modern arms, but it does no more. In savage warfare, however, it is not the enemy's fire which is the true source of danger, it is bodily contact with his greatly superior numbers that must be feared. Against this the shelter trench is no protection. If our fire can keep the enemy from closing, and in ordinary cases it undoubtedly can do so, well and good; but if not, no shelter trench that can be rapidly constructed will prove of any value. Once the enemy has closed, the shelter trench can be treated as non-existing, and steadiness and compact order can alone avail. These trenches may save a few lives during the earlier stages of the attack, and are not therefore to be despised. They assist also in marking the ground to be occupied in case of a night alarm. But however valuable as accessories, they are nothing more.

But though we are debarred from the use of fieldworks, or at any rate from placing any great reliance upon them, other precautions may be taken, and chief among them during the Zulu war was the system of laagering the waggons.

Roughly speaking, laagering the waggons consisted in arranging them in a ring, enclosing a space wherein the cattle were penned at night. The men were encamped round the outside of this laager, and in case of alarm they struck their tents and prepared to defend the waggons. This system had been extensively used by the Dutch in their former wars with the Zulus and Kaffirs, and generally with happy results. Fighting usually in small parties of 300 or 400 at most, the Dutch could seldom maintain themselves in the open against their powerful enemies, and numerous disasters taught them caution. Within their laagers, however, they were always safe, and the natives never attacked them there without being repulsed with heavy loss.

But defending the line of waggons itself is not without grave disadvantages. All power of movement is lost, and the enemy cannot be followed up quickly. Frequently, too, some parts of the line will have but a small field of fire, and the enemy will be able to creep up close to the camp without suffering loss. For these and similar reasons the men during the advance to Ulundi seldom occupied the line of waggons; but were placed in a shelter trench some 20 or 30 feet outside of it. It is evident that, for all practical purposes, the men in these trenches did not owe their safety to the line of waggons in rear of them, and all the protection provided for them was a simple shelter trench. Now I have already pointed out that a shelter trench affords no security against the chief danger of savage warfare; and it may be asked why, if this were considered sufficient for the purpose, was so much stress laid on laagering the waggons at all. The answer is, I believe, that, provided there be no surprise, fortification is unneeded against savage foes so far as the men are concerned; but that special precautions are required for the safety of the large transport train. I shall have more to say about the method of *fighting* the enemy when I come to deal with the question of tactics; here we are discussing the best way of providing for the safety of the camp and the transport train. By laagering the waggons and placing the bullocks inside them the whole was arranged in the most compact and most readily defensible manner.

Notwithstanding, therefore, all that was said and written after Isandhlwana, the columns did not depend upon *fortified* camps for its safety. The men were prepared to meet the enemy in the open, and at Ginginhlovo did so meet and defeat them. But to guard against the risk of a sudden rush, a proper system of outposts and picquets was required. It may seem unnecessary to draw attention to this; but I do not think it is so. For three months I lived in a fort on the border where there was a garrison, at first of 800 men, but subsequently of 500. At night every man was drawn inside the fort, a very confined space for so many men, and a large number of sentries (at first nearly 100) was posted on the walls. Crowded inside, without tents, and with a general feeling of insecurity, it was no wonder that many of the men died of fever. The reason given for the absence of all picquets was that, should the enemy come, the men on outpost duty would be certain to be cut off. Had this reasoning been applied to the camps, during the subsequent advance, it is difficult to see how their safety could have been provided for.

During the advance on Ulundi I was, on more than one occasion, able to see the result of a night alarm (always false, however) on the dispositions made by the 2nd Division. On an alarm occurring anywhere along the line of picquets, the men in camp at once turned out and rushed to their places round the laager. They were not as a rule fallen in on their own parades first, and for a few seconds there was wild confusion accompanied frequently by a random shot or two, fired usually, however, by some frightened native driver. In about a minute or so the whole were in their places ready to resist an attack. In the meantime the picquets had generally retired on the laager without waiting to be driven in. Now this action on their part produced a result which might have been very unfortunate for them. The defenders of the laager, knowing that the picquets would retire without waiting for the enemy, never expected any further warning to be given to them. If any firing took place in front they immediately took it for granted that it came from the enemy, and so commenced to blaze away at their own picquets, as occurred on a large scale at Fort Newdigate, June 6.

It thus happened that in endeavouring to avoid the danger of being cut off by the enemy the outposts exposed themselves to a fresh danger. Nor was this the only inconvenience caused. The men in camp lost all confidence in the protection afforded by the outposts, and their *morale* suffered in consequence. It would have been possible for a single Zulu to awaken the whole camp and destroy its night's rest for several hours by firing a single shot. A general feeling of insecurity pervaded the force, for it was felt that if the picquets were to be withdrawn at the first alarm there was nothing to prevent a sudden rush of the enemy reaching the main body before it could stand to its arms. Major Clery says, in his *Minor Tactics*, page 5: 'Outposts may be defined as detachments thrown out by a force when halted for its immediate protection from surprise. Its duties, therefore, are twofold, observation and resistance; observation, to give timely warning of danger to the main body, resistance, to afford it time to make dispositions for defence. Thus two points are gained of primary importance, security and rest. The latter only cedes in importance to the first, for without a due proportion of rest the physique of the best troops gets rapidly deteriorated.'

To delay the enemy is frequently of vital importance, and it is only when the troops in camp feel tolerably certain that the enemy will be delayed that confusion can be avoided in case of alarm. On the other hand, it is only when the picquets feel that their retreat will be fairly secure that they will remain at their posts. If it were true that with an enemy like the Zulus the men on outpost duty were sure to be cut off in case of an attack, it was not to be wondered at that they sought safety in retreat at the first alarm.

Undoubtedly there is more risk of such an occurrence in savage warfare than in civilised campaigns, but with due care that risk may be almost entirely removed. It should be remembered that outposts are perfectly capable of resisting the attacks of small bodies of the enemy, while a proper use of patrolling should always discover the proximity of large masses. I do not know what night patrolling was performed by the 2nd Division, but in the Flying Column mounted men were kept circling round the camp at a distance of about a mile in front of the picquets. It was always possible that small parties concealed in hollows would escape their notice, but it was not likely that any large mass of the enemy could have approached the camp without discovery. In order to give sufficient confidence to the outposts they must further feel that support, if necessary, will be sent out to aid them. But to do this the men in camp must be kept in hand. They must not be allowed to rush helter-skelter to the trench they are to defend; they must fall in and await orders.

It would appear, then, that the following regulations, or something like them, should be made for the conduct of troops in camp during an alarm.

(1) The outposts will retire on the camp only when forced to do so by pressure of the enemy or on receipt of orders.

(2) The troops in camp will fall in on their respective parades

with ordered arms, ready to march to their alarm posts in the laager, or to meet the enemy outside as may be ordered.

(3) In no case is firing to be commenced until the outposts in front have been driven in or have retired on the laager.

If we have learnt a lesson from the Dutch in laagering our waggons, it is possible that we may learn another from a still more antiquated system of warfare. The Romans, in their numerous wars with the savage nations around them, soon discerned the necessity for guarding against the rush of hordes of badly armed and undisciplined foes. In the daytime, and whenever a surprise was impracticable, they could put implicit trust in their discipline and their weapons. At night, and where warning might possibly be wanting, the results of a panic were greatly to be feared. It was, therefore, that they elaborated that system of surrounding their camps with a bank surmounted by palissades. At the present day it may not be possible to carry the great weight of the palissades with the army, but could not a substitute be found in a wire entanglement, to be placed at nightfall and removed in the morning. At one time there was some talk of adopting this plan in Zululand, but it was never carried into effect. As a matter of fact it was not found necessary, but with an adversary who combined the pluck of the Zulu with the cunning of the Red Indian, should such a foe exist, an auxiliary means of defence of this nature might be found of value.

Fortified Posts.

As the army advances into the enemy's country, it is necessary to form certain fortified posts at intervals, such as have been already alluded to under the head of transport. The influence of these posts is often far greater than one would be at first inclined to suspect. A force of 200 or 300 men, who scarcely dare lose sight of their fortifications, does not seem a very powerful weapon to employ in overawing a hostile district. As a matter of fact, however, it will generally be found that such posts do overawe the country, and that, especially after the army has proved its superiority in the field, their moral influence extends much farther than their physical power.

At these posts it will often be convenient to establish commissariat depôts. But the perimeter that can be defended by the small garrison left behind will seldom be large enough to enclose the space occupied by the stores. These must therefore be left outside, but they must not be unprotected. Several plans were tried during the Zulu war to overcome this difficulty, and of these some are shown in *Pl.* I.* The

* The details given of the construction of forts on the line of communications ar taken almost bodily from an article I wrote for the *Professional Papers of the Corps*

system usually adopted was that shown in *Fig.* 3. It consisted of two small square redoubts placed on the extremities of the diagonal of a square large enough to contain the stores. These were therefore defended on all sides by the flanking fire of the forts, while the size of the garrison required for the latter did not depend upon the amount of the former.

This system is, however, open to certain objections:

(1) The stores are too much massed; and many waggons cannot be loaded simultaneously.

(2) The garrison, already small, is subdivided.

(3) The interior space of the forts is very small compared with their perimeter.

With regard to this last defect, it must be remembered that a garrison of 200 or 300 men is unable to furnish an efficient system of picquets and outposts, and is, consequently, more or less exposed to the danger of a surprise. It would appear advisable, therefore, where, from the proximity of the enemy, an attack is to be feared, to bring the garrison within the works at night. Consequently, the interior space should be large enough to hold them comfortably. Where the garrison consists of about 200 men—a not unusual number—the forts cannot have a greater perimeter than 200 yards, which gives 25 yards a side. Forts of this size will be found too small to contain the tents of the garrison, and the men must therefore bivouac inside or encamp outside.

Fig. 4 shows a plan proposed, but never employed. It gets rid of the subdivision of the garrison, and will admit of the tents being pitched inside when necessary. But in order to give sufficient base for the triangles formed of the stores, an oblong trace is used, whereby there is a diminution of interior space as compared with perimeter. The arrangement of the stores is also little favourable to their easy movement, and if many waggons had to be loaded in a hurry, much confusion and delay would occur.

The system shown in *Fig.* 5 was one which I proposed, but it was never employed. In this case the fort is square, thus giving the *maximum* of interior space for a given perimeter, but of course its trace may be varied to suit the features of the ground. The stores are arranged in long lines, radiating from the faces, say eight or ten feet thick, and 6 feet high. They may, if necessary, extend 150 or

of *Royal Engineers* during the Zulu war. Notice of this paper having been received by the Editor never reached me, and, thinking that the paper had miscarried, I made use again of the notes I took during the war. The article was, however, published in Vol. IV. of the *Professional Papers*.

200 yards from the fort, and, where the ground is level, even farther. The advantages of this plan are:

(1) The stores can be more easily looked after, and it is impossible for a man to conceal himself among them for the purpose of stealing.

(2) A large number of waggons can be loaded up at once.

(3) The stores can be so arranged that any particular article that may be required can be obtained without difficulty, which is certainly not the case where they are massed in a confined space.

(4) They can be easily defended from the fort.

(5) They form a considerable obstacle to an enemy attacking the fort by prohibiting flank movement on his part. In fact, they form perpendicular obstacles terminating in front of the line.

In determining the profile to be used it must be remembered:

(1) That the main object is to oppose a considerable obstacle to the enemy's endeavour to arrive at close quarters.

(2) That artillery fire need not be feared, and that consequently exposed escarps are not objectionable.

For the first reason full revetements retain all their old value, for the second demi-revetements lose theirs. Thus when Fort Melville, at Rorke's Drift, was being constructed, a portion of the *enceinte* was made with an ordinary earthwork profile, the interior being reveted with dry stone-walling, there being plenty of large loose stones lying about. While the work was in progress it was suggested to revet the exterior, as well as the interior, so as to add to its strength as an obstacle. This was done, and then the uselessness of the mass of earth enclosed between the two walls became evident, and the remainder of the *enceinte* was built of a dry stone wall only.

In all other cases where stone was handy similar walls were always used. Where stones were not to be obtained turf walling was employed, but this gave considerable trouble, as the soil was loose and the sods gave way in the heavy rains. Brushwood revetements (exterior as well as interior) might frequently be found advantageous, but in Zululand brushwood was not obtainable. In all cases where possible use a wall in lieu of a parapet, but where no material for the construction of one is at hand a good ditch must furnish the necessary obstacle.

Flank defence, however useful, cannot be considered as a necessity. So long as the defenders are sufficient in number to man the walls thoroughly and provide a small reserve for casualties and emergencies, they ought to be able to hold their own against any force the enemy can bring against them. So long as the man outside has to use his hands to climb over the parapet, he is at the mercy of the man inside.

I know of no instance of a fortified post being captured by an uncivilised enemy by direct assault, and it is difficult to conceive how it could possibly happen. The Indian Mutiny will afford any number of instances of the resisting power of even slight defences, while Abrakrampa, Rorke's Drift, and Mohalis Hoek are more modern examples.

Three requisites must be looked to if we would insure a successful defence—water, ammunition, and provisions. It will seldom be found possible to have a supply of water inside the fort; at least, in most instances, it will be found that to do so the fort must be placed in a hollow. But so long as the watering place is not far off, *and is under fire*, there will be but little inconvenience caused by this.* As for the ammunition, of course a large stock (that is a large number of rounds per rifle) should be available, and this ammunition should always be within the fort. Of provisions nothing need be said here.

PRECAUTIONS FOR THE DEFENCE.

Although I have dwelt on the necessity for providing sufficient space for the tents of the men *within* the fort, it by no means follows that they should habitually sleep there. On the contrary, it is essential for the health of the men that they should, as far as possible, sleep outside, except when the proximity of large masses of the enemy makes an attack likely. But if they sleep outside, outposts of some sort must be thrown out. These outposts, however, will not be strong enough to perform all the duties usually expected from picquets. They may undertake that portion of them comprised under the head of 'observation,' but 'resistance' can scarcely be expected from them. However unlikely, therefore, the possibility of a sudden rush of the enemy upon the fort must always be guarded against, and for this purpose a small garrison should always be within it. Now, as no resisting power is expected from the outposts, it would seem rational to reduce these to mere double sentries, keeping their relief inside the fort as its garrison. Thus, say six double sentries are required outside, and two ordinary sentries in the fort, there will be a force of 30 men, and say four non-commissioned officers permanently inside, a sufficient number to check a first rush.

* Of course there must be a certain amount of water stored in the fort, tanks or water-casks being used for this purpose. But experience shows that uncivilised foes are seldom, if ever, capable of closely investing a post, and, if the watering-place be within easy range, there will be little or no difficulty in renewing the supply as may be required.

In Zululand we used sometimes to put out groups of six men, each furnishing a double sentry, and each under a non-commissioned officer. Of these four were always sound asleep under improvised shelter tents made of blankets, and I know that when going the rounds it was often hard enough to waken these men. This I believe to have been a mistake, as it was only exposing the slumbering men to a needless danger; and, except where the post is too far out to be conveniently relieved from the fort, I believe it would be better to keep the men inside, as advocated above.

In case of an alarm the men should, if possible, be fallen in outside the fort near its entrance, with ordered arms, but of course the danger may be too pressing to admit of this. Where, however, there are mounted men—and these should in every case form a part of the garrison—patrolling should always be carried on, and then a sudden attack from *large* numbers should be impossible. Attacks from small numbers may be met outside the fort, and then more decisive results will usually be obtained.

There is one point in connection with the defence of a fort as to which considerable difference of opinion seems to exist, and that is, the advisability of using loopholes. These add greatly to the safety of the defenders of a work, but they certainly detract much from their offensive power. Considering the small effect produced usually by the enemy's fire it would certainly seem wise to provide some means of allowing the men to shoot over the parapet, but loopholes should also be provided to be used when the enemy's fire is exceptionally hot. One means of doing so would be to provide a banquette for firing over the parapet or walls standing, with loopholes at kneeling height. Another method, employed by Major W. P. Jones, R.E., in the fort built at Dundee, was to have loopholes at standing height with small banquettes between them for firing over the wall.

One of the great difficulties connected with these fortified posts is to provide for the safety of the horses and cattle. These cannot well be admitted inside the fort, and so some special means of defence must be provided for them. The simplest plan would appear to be to provide a redan-shaped enclosure flanked by the fort in which they can be kept. To prevent this enclosure masking the fire of the face opposite which it is placed, it will be advisable to sink its floor some two or three feet below the level of the ground, providing drainage where possible by a cutting to the nearest hill side. Where proper drainage cannot be otherwise provided a deep cesspit may be dug, and drains made to it.

Tactics.

In dealing with this, the second branch of the subject, one is at once met with a considerable difficulty. The rules of tactics are at all times exceedingly difficult of application to general cases. The circumstances of each instance must determine the tactics to be used. In savage warfare these circumstances are more than ever variable, and it follows that the proper tactics must be so also.

The golden rule of fighting uncivilised foes appears to be, first study your enemy's habits, and then determine on your method of meeting him. Many men who have seen Indian warfare will hear of nothing but offensive action, frequently of a pell-mell nature, anything to get at the foe and remind him of the superiority of the European. Others, who have seen the Zulu campaign, can realise nothing but a hollow square charged by a crowd of savages who are shot down by hundreds as they vainly attempt to close with their foe.

It would be impossible within the limits of an essay to discuss every possible case that might arise; and I will, therefore, confine myself to some few of the principal classes of action which usually occur.

But before proceeding to the discussion of particular cases, there are a few observations which I wish to make on battles with uncivilised foes in general. One point that cannot fail to strike even a casual observer, is, that while in every case where the victory is ours, it is gained with but little loss, defeat and disaster are synonymous. This fact must make us chary of drawing absolute inferences from the victories we have gained. Unless the evidence obtained from native sources be absolutely false, Isandhlwana was very near being a great and almost bloodless victory for us. The Zulu army, discouraged by its heavy losses, was very near retiring from the contest, and had it done so its loss in retreating would have been very great. A feather would have turned the scale, and yet the result was a disaster to our arms of the first magnitude. It does not require a great stretch of imagination to picture to oneself the writer on military matters gravely drawing deductions as to the right method of meeting the Zulus from the tactics employed on that day. But the scale was turned, the disaster occurred, and we are, or think we are, wiser.

I remember, some years ago, talking to an officer who had been at Amoaful, and I was surprised to hear him say that at one moment he thought matters very critical. Now I, in common, I fancy, with most young officers who have never seen any fighting of this nature, had always judged of the Ashanti war by the small loss inflicted on our men, and I have been accustomed to regard the fighting as mere child's play. And yet it is very possible that at one period of the battle, it would not have required much to have converted that decisive victory into a terrible disaster.

As a rule, our savage wars are fought against immense odds, and in such cases hand-to-hand fighting must always prove dangerous. So long as the enemy can be prevented from getting *among* our men the danger is small, but when from any cause the enemy's numbers can be made to tell in individual fighting at close quarters, the result is destruction. The main object of all tactics in warfare of this nature must therefore be to avoid this danger. But there is a further object of scarcely less importance, and that is to inflict loss upon the enemy. Unfortunately these two objects are more or less antagonistic, and unless a happy mean can be hit between them, the result will not be satisfactory. There are occasions when audacity, always audacity, is the right game to play, but there are also times when audacity must be strongly modified by caution. To judge the right policy to be pursued, it is necessary to know something of the enemy; but this much may be said, if it be safe to use essentially offensive tactics, the task before the army is usually comparatively an easy one. Remembering how easy it is for the enemy to outflank our columns of attack, it is evident that unless the success of the movement is practically certain, or that it is known that the enemy will not follow up our retreating men, if they have to fall back, it will be unsafe in the extreme to push home an attack. Partial advances may be made to drive the enemy from this point or that, but a regular assumption of the offensive will not be wise. Circumstances may compel us to run any risk, but in doing so we should not blind ourselves to the fact that these risks are being run.

But if we meet the enemy drawn up in position, whether on an open plain or along some chain of hills, are we merely to form up our army in a similar manner and wait till it please our adversary to open the ball? Assuredly not. Circumstances can alone decide how far an assault of the enemy's position will prove necessary, but in any case there is much that can be done without compromising the safety of our force. For this purpose three weapons are at our command—Artillery, Cavalry, and long-range Infantry fire. In many cases, perhaps in most, it will suffice to shell the enemy's position, keeping the Cavalry ready to charge in directly his men begin to give way. In the meantime the Infantry may be formed up at, say, 1,000 or 800 yards, or even less, according to circumstances, and by a carefully supervised fire may add greatly to the effect produced by the shells. Such Fabian tactics will seldom fail, except in very mountainous or other cover-giving country, in bringing on one of two issues. The enemy will either retreat with greater or less loss, or he will endeavour by an attack to get out of a situation where he suffers loss without the possibility of an effectual reply. In the former case follow up sharp with all mounted men *and guns*, the Infantry also advancing as rapidly as is consistent with safety. It is, however, hopeless to expect the British soldier to compete with the savage in a running fight. The black man can walk round him as he will, and, even if overtaken, his superior numbers will tell if the fight be hand-to-hand. So long as fire tactics can be used, superior arms and superior discipline must tell, but when it comes to cold steel, the enemy, *if he wait to receive*, must have the advantage.

I have italicised the words 'if he wait to receive,' for therein lies the kernel of the matter. Indian officers know, from long experience, that the enemy they have to fight with will always give way before a charge given with decision. How far their ideas may have been altered by the Afghan war remains to be seen, but, even there, victory after victory rewarded the pluck of our men. It is true that our disaster at Maiwand is attributed by some to the defensive tactics employed, but it must be remembered that the Afghan is a semi-civilised foe, and not an uncivilised one.

In dealing with other uncivilised nations, the certainty that they will give way before a charge made by our men is by no means so great. Experience shows that that portion actually charged will almost invariably yield ground; but what then? Conceive the result of a comparatively small body of men penetrating into the mass of the enemy, becoming enveloped by them and fighting against great odds at close quarters, and the peril of the situation becomes apparent. Where, therefore, the enemy has sufficient organisation to keep together in some sort of close formatiom, the use of the bayonet as an offensive weapon must be given up. The troops may *advance* against the foe, but they must not charge home. But, on the other hand, the enemy when in close order will afford an excellent mark for both rifle and shell, and will soon be made to pay heavily for his immunity from the charge. Scatter he must, or advance to the attack. The latter contingency we may neglect for the moment; it will be dealt with when we come to defensive tactics. If he scatter, the danger of charging is to a great extent removed. He may then be driven from advantageous points at the point of the bayonet, and a succession of partial charges aided by rifle fire may put him to rout.

But even in this case the danger of the enemy collecting for a general rush must always be held in view, and our men must always be prepared for an assumption of the defensive. To send out single companies unsupported, as was done at Isandhlwana, is to court disaster; for, once surrounded, they must either come to hand-to-hand conflict in the endeavour to force their way out, or they must remain where they are till their ammunition is exhausted.

In the old Dutch wars with the Zulus, we are told that the system of fighting found most efficacious was as follows: The whole of the Commando, as the column was called, was composed of mounted men, and most of them were first-rate shots. Having laagered their waggons and left a guard to defend them, the Commando would set out to meet the enemy, and engage him at long range. The superiority of their weapons and the accuracy of their shooting combined to give them a great advantage so long as they kept the enemy at a distance. Their shots told, his missed. They seldom or never lost a man, he was continually suffering loss. If he attempted to close they remounted their horses and retreated to a safe distance, reopening fire as soon as possible. Keeping up a running fight in this way they gradually wearied out the natives, causing them considerable loss in the meantime. When tired of this unequal combat the enemy commenced to retreat, they followed him up with a perpetual fire, which gradually converted his retreat into rout. If worsted in this running fight, they slowly retired on their laagered waggons, and defending themselves there, seldom failed to drive the enemy away with severe loss.

It was frequently suggested during the Zulu War that these tactics should be once more tried; that the whole of the mounted men of the army should be sent forward to make a dash at Ulundi, and that in case of meeting with resistance they should engage in a running fight of this description. This method of procedure did not find favour with the authorities, and justly so. Putting aside the moral effect of a regular occupation of the country by the army, it is very doubtful whether these mounted men could have inflicted the same loss upon the enemy in a fortnight's fighting, that half an hour's Infantry firing did on the banks of the Umvaloosi. They might, it is possible, have got to the king's kraal; they might also, but it is doubtful, have driven the Zulus from it, and have fired it. But the terrible lesson that was taught the natives of the power of the Martini-Henry in the open, would have been withheld, and I cannot but believe that that lesson was necessary to bring the war to an early close.

However well-mounted men may work in really open country, they are powerless in bush countries, while even on the apparently level 'veldt' of South Africa they would frequently be much hampered by the 'dongas,' or dry watercourses, which intersect the country. It is very easy to talk of annoying the enemy with distant fire to which he cannot reply, but those who talk lightly of doing so forget that even a savage may adapt his tactics to suit the moment. He will not be likely to remain a helpless target to our mounted men in the middle of ground just suited for our horses, but will choose a broken or hilly country wherein to fight.

Even where the enemy is obliging enough to give us every chance, it by no means follows that the task will be easy. It must be remembered that every man who falls into the enemy's hands is a dead man, and that his death is often preceded by torture. These facts are well known to our men, and indeed are frequently exaggerated in their imagination. It is hopeless, therefore, to expect them to stand under a heavy fire unless there be some means of providing for those who are wounded or whose horses are shot. Mounted men attempting to carry out Dutch tactics must abandon their wounded, or retire before there are any wounded to abandon. Now, in the good old days, the savages had no weapons save the assegais, consequently there could be no wounded men to abandon, unless the enemy was allowed to arrive at close quarters. But at the present day this is by no means the case. It is true that the fire of the Zulus or the Basutos is inaccurate in the extreme, but still it is not without effect. It is as far-reaching as our own, and we cannot insure inflicting loss upon the enemy without exposing ourselves, at least in some degree. Unless then our men know there is some safe place near at hand, to which their comrades who fall can be carried, they will scarcely remain long under the enemy's fire. All men are not heroes, and there are few who can contemplate with equanimity the certain result of falling into the hands of a savage foe.

Still worse will it be when rough and stony ground has to be traversed. Much of the country worked over in Zululand was sown with large loose boulders, or semi-embedded jagged stones, in such a manner that the lithe native could cover the ground even faster than a horse. In such country the Dutch tactic would fail, for the enemy could always close with our men if they tried to retreat. On one occasion only did I see a large Cavalry force engaged with the Zulus, and that was during the Cavalry reconnaisance, the day before the battle of Ulundi. Certainly the results of that day, however satisfactory so far as the object immediately in view was concerned, did not tend to increase one's belief in the Dutch tactics.

On that day the mounted men under Colonel Buller, to the number of some 500, crossed the river, partly to clear the opposite bank of the men who were firing at our watering parties, partly to discover the strength of the enemy, and partly to learn the nature of the ground on which the decisive battle was to be fought. On first crossing but small bodies of the enemy were seen, and these quickly retired or hid themselves. After advancing about three miles, Colonel Buller found himself suddenly in the presence of 4,000 or 5,000 of the enemy who had been concealed in a 'donga' or dry watercourse, and who poured in a volley at 200 yards range. It is true that but few men were hit; but the reconnaissance was at once stopped and three men supposed to be dead (they were dead enough when found next day) were left in the hands of the enemy, two more being saved by the gallantry of Lord W. Beresford and Commandant D'Arcy, who earned the Victoria Cross by their conduct on this occasion. When the Cavalry returned, their horses were done to a turn, and I doubt whether that force would have cared to have gone many miles from the laager to engage the enemy. It is true they had not lost many men, but feeling that, with every horse shot, a man would fall into the enemy's power, I doubt whether much of a running fight would have been got out of them. Besides, if but few men were hit, it was because they did not remain to give the enemy a chance. They were but a reconnaissance and they acted rightly; but I do not think they could have done differently if they had intended a serious attack.

Having thus stated my own views, it is only fair to give those of the other side—views which certainly were received with much favour in the unofficial Councils of War among the junior officers of the army. These were well expressed in a letter from Kambula camp, dated April 15, sent to one of the daily papers, the name of which I do not remember.

'The long experience of the Boers has demonstrated that, to deal effectually with Zulus, white men must be mounted. The marching power of these athletic savages is so marvellous that it would hardly be an exaggeration to say that they, naked and carrying no weight, would cover five miles of ground while a British Infantry man, strapped up and weighted with his kit, would be toiling over one. It is not only that the white man needs to be mounted to compete with the Zulu in mere power of locomotion; but the odds against which he is called upon to fight make it absolutely necessary that he should be able to accept or decline a combat. The catastrophe at Isandhlwana shows what might be expected to occur when a small force once becomes encircled by the horns of a Zulu impi.

With mounted men, however, it is very different; on anything like good ground they gallop up well within range, dismount, fire into the mass of the enemy with practical impunity until their proximity becomes dangerous, then mount and away, to play the same game over and over again. Instances have occurred here, more than once during the present campaign, in which a troop of irregulars has bullied a large force of Zulus in this fashion, killing more than their own number of the enemy with no loss to themselves beyond a few trifling wounds to men or horses.'

I cannot remember the instances here alluded to, and I am certain they never occurred when a large force of the enemy was encountered; and I am still strongly of opinion that a body of mounted men, without some secure place on which to fall back, would never succeed in carrying out these tactics. At the same time combined with the use of a laager, or of a body of Infantry capable of holding its own defensively against the enemy, mounted men used in this way will frequently give an offensive character to the action which would otherwise be wanting.

As an example of the successful use of these tactics, we may take the relief of Mafeteng* (*Pl.* III.). It is true that in this action the 1st Cape Mounted Yeomanry fell into a trap and lost heavily, but on the whole the action of the Cavalry was eminently successful. The greater part of the fighting devolved upon them, and, with the exception of one occasion, when the enemy managed to get near the flank companies of the Duke of Edinburgh's Own Volunteer Rifles, they succeeded in keeping him at a respectful distance, occasioning him at the same time considerable loss. Had the Basutos shown greater determination, the Cavalry could always have fallen back on the main body, where a defensive action could have been fought. When this had ended in the repulse of the enemy, the Cavalry could once more have advanced and followed him up according to circumstances.

So far we have looked upon these mounted men as mounted Infantry only, and undoubtedly it is in that form that they play their chief part. But their sphere of utility does not end here. If trained to act as Cavalry, there are many occasions in which a charge may lead to decisive results. If the advance of Infantry carry with it a great moral effect, a Cavalry charge carries even more, and there are few savages who will stand one if it be delivered with due energy. A little farther on I shall have more to say on this subject in connection with defensive tactics; here I note the fact that the use of Cavalry as Cavalry is not debarred by their more frequent use as mounted Infantry.

* In the late Basuto war.

Few questions were more debated in the army after Isandhlwana, than the proper method of handling Infantry against a numerous and brave, but uncivilised, foe like the Zulus. From the open order and widely scattered line of the 24th Regiment, to the serried square of Ulundi, was a great step, and it marked the change of opinion produced by the Zulu victory. But I fancy few of those who stood in the square at Ulundi were satisfied that the last word had been spoken on the subject. The formation adopted was more or less suited to the problem that had to be solved, but it was not one of universal application. It might answer in a level plain so long as the enemy was kind enough to advance boldly in the open. It must fail in broken ground or where the enemy has to be attacked. One cannot conceive Morosi's mountain or Sekokuni's stronghold being captured by a hollow square, and yet these both fell but a few months later. The frontal attack must sometimes be undertaken, and it is necessary to consider the formation best suited for it.

In dealing with this question, the first point to be remembered is that in closing with the enemy, there is little or no danger to be feared during the early stages of the attack. Indeed, it is not till we arrive within reach of a sudden rush that the movement is attended with any risk. It follows, therefore, that it is quite unnecessary to adopt skirmishing or open order as a means of avoiding the effects of the enemy's fire. So far as that is concerned, we may carry out the advance as we like. But as we near the enemy's position, the risk of a sudden rush in overwhelming numbers continually increases. To expose men in individual order to this danger is to court disaster, for each man may be surrounded and slain. If kept in hand, however, in close order, the danger is for a time removed, and if ammunition hold out, or if relief be at hand, it is altogether obviated. A single man with a bayonet falls an easy victim to half-a-dozen savages with assegais, but a hundred men in line can hold their own almost indefinitely against ten times their number. The gallant stand of Younghusband's company at Isandhlwana, is a good example of the safety resulting from close order, but the disaster of that day is a warning against allowing an overwhelming number of the enemy to get *among* our men while in open order.

But the simultaneous advance of a long deployed line over a considerable distance, is by no means an easy matter, and the necessity for keeping up a heavy fire during the advance does not make it easier. Besides, if our men advance in line two deep, even without allowing for second line and reserves, they will show but a comparatively small front; they will be out-flanked and eventually surrounded. To obviate these defects, it would appear advisable to divide the line into sections, perhaps double companies, with intervals at least as great as the front occupied, with a similarly formed second line of perhaps half its strength; the advance will be made by the more or less independent movement of these sections, care being taken, however, that the general alignment is preserved. Each section will be kept in close order, and if need be, can be formed four deep on the principle of company squares. If the enemy advance to the attack before the final charge is delivered, each section will be capable of prolonged resistance, even when surrounded, owing to its formation, while the second line can be employed to disengage any portion that is in difficulties.

After arriving within charging distance, a heavy fire should be maintained upon the enemy until the favourable moment arrives to bring matters to a crisis. This will occur when our fire has so shaken the enemy that he shows signs of wavering. The charge should then be made, still in close order, by a simultaneous advance of the whole line, the second line, however, keeping at safe distance in case the assault should fail. This failure should, however, be impossible, for as there can be no reason for bringing matters to a head until our fire has had due effect, nothing but impatience should lead us to close with the enemy until he is on the point of retiring. When the adversary is already wavering the charge will certainly produce the desired result.

The real danger to be guarded against is that of the enemy advancing to the attack before our fire has had time to destroy his *morale*. In this case the second line should at once be moved up to the intervals of the first line, reinforcing that portion of it most strongly threatened, and each section must defend itself. It is not likely that the enemy will be able to surround our double companies, although he may penetrate between them. It is attributing to him greater pluck than is possessed by any nation of whom we know to suppose that he can maintain himself at close quarters for any length of time, even in front of the line, between two fires it would be impossible. It is generally admitted in all books on tactics that the crisis of the attack cannot last more than two or three minutes, and that within that time the assaulting troops must succeed or retire. But in this case the native has no means of bringing about a rapid success. His fire is too feeble, he cannot break our company squares by mere weight. But unless he can succeed in a few minutes, he must fall back or be annihilated.

It may be urged, however, that our company squares will fire into one another. Well, if we can conceive the enemy really closing on our men, penetrating between the squares, and remaining surging close around them, this may undoubtedly take place. But is such a case conceivable, except when a disaster has already nearly taken place? If we have so miscalculated our strength that the enemy, by his overpowering superiority of numbers, is able to close in this manner, we may consider ourselves lucky if we eventually put him to flight, even with a heavy loss to ourselves produced by our own fire. But even in such a case as Isandhlwana this does not seem to have occurred. According to all accounts the fire of our men was perfectly able to check the enemy's advance until the breaking of the Native Contingent left some 800 men in extended order to cope with 20,000. Even then it is doubtful whether they would not have maintained themselves had they not been taken in rear by a fresh party of the enemy, and thus found themselves between two fires *while not in a formation capable of defence in both directions.* I believe that if we adopt a formation that will prevent our men from being swept away at the first rush when the enemy attempts to close, his failure is certain. It will not be many moments before he falls back again to a respectful distance, and though his final defeat may not have been accomplished, a fair chance will once more be afforded us of pursuing our own object.

Should it become necessary to retire before the enemy is broken, care must be taken not to afford him an opportunity of falling unawares upon our retreating men. Retiring by alternate sections would appear to be the safest plan, or where the second line is intact, by alternate lines.

The main principles of an attack of this nature would therefore appear to be as follows:

(1) Full effect must be given to our superior fire before any attempt is made to close with the enemy.

(2) Where the enemy is exposed in the open, it will seldom be necessary to deliver an actual charge until he is on the point of breaking, although it may prove necessary to advance to closer quarters than those first taken up.

(3) When, from the nature of the ground, the enemy is protected from our fire, the attack may have to be carried out to the very end. In this case, however, the natives will seldom be in a position to use large masses suddenly, and the danger will, therefore, be somewhat reduced.

(4) While it may not be necessary to form the whole force in one compact mass, each fraction of it must be kept in close order when in dangerous proximity to the enemy.

(5) If the enemy attempt to rush, the men must be cautioned that they are safe as long as they stick together, but that if they break they are lost.

(6) Small compact bodies, even when surrounded by the enemy, are not necessarily confined to the spot on which they stand. The enemy cannot live long in actual contact with them, and when they give way, a retirement or advance will always be possible.

(7) To clear a hill, or any other given point, of a comparatively small body, the bayonet may be used. To defeat an *army* of natives the rifle is the true weapon.

(8) The use of Cavalry as an auxiliary will frequently be very advantageous. It is seldom that a savage foe can stand a regular charge, and if one be given with due energy, it will frequently prevent the Infantry being surrounded or disengage them if they are already hemmed in.

Although it may often be advantageous to attempt an offensive movement, such as that described above, there must always be a defensive element in all actions with uncivilised foes. What has already been said about the advance into the enemy's country, applies equally to the advance of an assaulting column. In neither case is the ground in rear of the troops covered by their advance. Arrangements must therefore be made to defend the convoy which accompanies the army, and to preserve some secure place for the field hospital and non-combatants. This place will also form the refuge for the assaulting column if obliged to fall back, and in it a defensive action can be maintained, until the enemy is defeated by sheer loss of numbers. In many instances it is here that the true battle is fought, the remaining operations being confined to skirmishing for various objects; such as driving back small parties of the enemy that are annoying the column from some vantage point, drawing on the enemy to bring him under the fire of the main force, and following him up when he retires discomfited. In some cases, as at Ulundi, this defended space is a fixed one, the army being drawn up merely with the purpose of resisting the enemy's attack. In other instances, as at Amoaful, or the relief of Mafeteng, the whole body moves slowly forward, fighting as it goes. In either case the main principles are alike.

Such a formation would be adopted in the following cases:

(1) Where it is necessary to carry the column in safety to a given point, and where attacks may be expected upon it from any direction.

(2) Where it is tolerably certain that the enemy is about to attack, and where, consequently, there is no necessity to do more than await his assault.

As an example of the first we may take Napoleon's army surrounded by Mamelouks in Egypt, the battle of Amoaful, and the relief of Mafeteng; of the second, the battle of Ulundi is a good specimen.

Napoleon in Egypt found himself exposed to the attacks of an overwhelming number of Mamelouks, men who combined skilful horsemanship with expertness with the sword. But they were capable only of shock tactics. They put their whole trust in their horses and swords, and knew not the value of the gun. Against men in line or in loose order they were formidable foes, all the more so that the musket of that day had not the same stopping power as the modern rifle. Napoleon's soldiers soon came to fear their unaccustomed enemy, and to attribute to him even greater powers than he possessed. It became necessary to adopt some formation capable of meeting the peculiar features of the case. The plan adopted was to form the army in large squares, a division in each square, with the guns at the angles. These squares were large enough to contain within them the ammunition, hospital, and other waggons with the army, and also the Cavalry, the latter not being powerful enough to hold its own in the open. The Mamelouks charged these squares repeatedly, naturally without success. At each charge they lost heavily, and in the long run they became demoralised and defeated.

Here we have evidently very much the same state of things as occurred during the Zulu war; the same feeling of insecurity pervading the men unless formed up in a compact mass; the same immunity from danger when once such a formation had been adopted. It must be noted, however, that these large squares had but little offensive power, that they were unwieldy to move, and that, large as they were, they could not contain the baggage train of an army.

The battle of Amoaful was essentially a bush fight, and consequently differed greatly in character from the other examples I have chosen. Here there was no chance of combined movements on a great scale made by the enemy, for the bush which stopped our troops was a hindrance also to the enemy. At the same time the enemy was very numerous, and it was essential that preparations should be made to meet his attack from whatever side it might come. To allow for this a circular position was first taken up round Egginassie. The line was formed of companies, in close order at considerable intervals, with a comparatively small force held in reserve in the centre. As there was but little chance of producing good effect from the fire of men in close order, owing to the concealment of the enemy's movements by the thick bush, it became necessary to throw out a line of skirmishers in front of the companies. In doing this there was but little risk, as the main line, behind them was not far off; at the same time it is as well to note there would have been no necessity to run even this semblance of a risk in the open.

By this arrangement the troops surrounded a considerable space of ground round the village of Egginassie, thus forming roughly a hollow square. Sufficient space having been gained to either flank the intention was for the whole to advance in three columns, the men forming the sides of the square being the flank columns, the front of the square the centre column. The bulk of the men in the rear face were to be left in Egginassie as a rear-guard, but they were to send forward two companies to follow the advance at some distance to prevent the enemy from taking it in reverse. The front face was also to drop behind two companies with the same object. During the advance, as was natural in a bush country, much of this formation was lost; and before half a mile had been accomplished, the flank columns had joined the centre one, and the whole force had formed line to the front with the exception of the companies detached to guard the rear.

As, however, the Ashanti army had retreated before our men, no inconvenience was caused by this, and Amoaful was reached without mishap.

In this action, therefore, we see the principle of Napoleon's squares once more put in practice, but modified to suit the circumstances of the case. The necessity for enclosing a space wherein the wounded and non-combatants could be placed was recognised, but the nature of the country, combined with the character of the enemy, did not necessitate a compact formation for the whole army.

Again, if we turn to the relief of Mafeteng, we find the same guiding principle, modified, of course, to suit the particular case. Here a convoy of some fifty ox-waggons had to be taken through a hostile country infested by a numerous foe, whose attacks might come from any quarter. The number of troops available to guard the waggons was not sufficient to enable them to form a continuous cordon round them, even had that appeared advisable. The men were, therefore, divided into four bodies placed one in front, one in rear, and one on either flank of the convoy. In case of an attack, any one of these bodies, being kept in close order, could resist the enemy long enough to allow assistance to arrive from the remainder of the troops. If the enemy attacked with his whole force on one side, the whole of the troops guarding the convoy could soon be concentrated on that side to meet him. If he attempted to attack on all sides at once, he could not be strong everywhere, and then each body of our men could have defended itself.

But in order to introduce some element of offensive tactics, as well as to discover the intentions of the enemy, three parties of yeomanry preceded the column, one on the road by which it was moving, one on either flank. In the result the Basutos never really attacked the column, but confined themselves to hovering near it and maintaining a hot but useless fire upon it from a distance. The yeomanry repeatedly advanced against them, and occasioned them some loss by their fire, but on each occasion the enemy fell back. Once a body of the enemy, slipping round the flank of the advanced parties, attempted to close with the column, but a single well-directed volley drove them back. Once also one of the advanced parties, following up some retreating Basutos, fell into an ambush. The Basutos retired up a hill and disappeared behind the crest. The yeomanry, in eager pursuit, dashed over the same crest only to find themselves at close quarters with a party of the enemy ten times their strength. The usual result followed. The party was almost annihilated, and thirty-five men paid the penalty of their rashness.

If we turn from these examples of actual warfare to consider what would have occurred had the column that advanced on Ulundi been attacked while on the march, we are at once met with a difficulty. I have already described the arrangements made for defending the convoy by laagering, but this plan by itself would have entailed the cessation of the advance. It would have been quite possible to conceive the Zulu army hanging around the column, threatening an attack but never delivering it while the waggons were laagered. To unlaager and proceed on the journey would have been highly dangerous, as the column of waggons was too long to be efficiently guarded by the number of men with it. But to remain waiting for an attack which never came would not have been possible. It is here that the action of mounted men, aided by guns, would have proved most useful. Advancing to within easy range of the enemy, they could soon have occasioned him so heavy a loss that he would have been obliged to bring matters to a head. He could not have remained quiet, but must have retired, or advanced to the attack. There can be but little doubt that the latter would have been the course chosen, and then the problem before the army would have become merely that of defending a laager against an attack. If the enemy retired he should have been followed up and driven away to a safe distance; indeed, a pursuit of this nature should be maintained as long as possible, perhaps even for days, although in that case precaution must be taken to prevent the pursuing troops being cut off by a fresh concentration of the enemy.

It is quite possible, however, that an attack on the column could have been beaten off without having recourse to laagering at all, by employing the tactics of the Mafeteng relief columns; certainly would one be inclined to think so against any savage foe who had not proved his metal like the Zulus. For this purpose, the first thing would be to close up the column as far as possible, marching the waggons as many abreast as the nature of the country will permit. The available troops should then be divided into parties, one in front, one in rear, and one for every quarter of a mile in length of the column. These parties should not be less than 300 or 400 in strength, and should be kept in close order. In case of an attack they would usually be able to defend, not only themselves, but also that portion of the column intervening between them and the next party. It is, of course, just possible that a very determined enemy would succeed in reaching the waggons and slaying a few of the oxen; but they would pay dear for their temerity, and it is scarcely conceivable that they could maintain themselves at such close quarters long enough to do much mischief. Of course, if we must give credit to our enemy for that wonderful pluck, contempt of death, and I had almost said invulnerability, with which the Zulus were supposed to be gifted, such a plan of action would seem rash. Laager and defend yourselves must then be the cry, and farewell to all initiative or rapid movement on our part.

Where defiles had to be passed a further difficulty would have been encountered, as then the column could not have been closed up, but would have straggled over many miles of country. To overcome this difficulty a different plan would have been necessary, for a long defile to that employed for a short defile. In the former case the *safest* plan would have been to laager the waggons at the entry of the defile, and leaving a sufficient guard for them, to take the remaining troops on to attack the enemy. Once defeated or driven away, the enemy would not hinder the passage of the convoy. But to do this might, in some cases, cause a delay which would be fatal to the objects of the expedition; and a simpler way might possibly be found in taking the convoy through in sections. Forming laager at the commencement of the defile, as many waggons as could be safely guarded when strung out at the greatly increased intervals (which would be inevitable), by the men available, might be sent through it, to laager on the far side. A garrison being left in the new laager, the remainder of the escort might return and bring a fresh section with it, and so on. Some such system might have been necessary had the enemy endeavoured to delay our march through the bush below the Entonjaneni, but unless the enemy shows greater skill in warfare than the Zulus, it may be possible to advance without having recourse to so many precautions.

Where the defile is but a short one, the only change in the ordinary method of advancing which has to be made is to halt the leading waggons until the tail ones are through, thus avoiding any opening out of the column. As this, however, will cause a considerable delay when the number of waggons is great, it may frequently be omitted if there be no fear of attack.

When several such short defiles have to be crossed in succession, the leading waggons need not be halted till they have cleared the last, provided always that the distance over which the column then extends is not too great for defence.

In the foregoing pages I have discussed some of the chief points connected with the advance of a column in contact with the enemy, together with the tactics to be employed on the offensive. I propose now to consider defensive tactics, and the more or less defensive battles where the army takes up a position and awaits the enemy's attack. Of this class we may take the battle of Ulundi as a good example. On this occasion a force of 4,000 whites, 1,000 natives, and 14 guns advanced into the plain surrounding the great military kraals with the intention of accepting, rather than giving, battle. It was known that the Zulus were present in large force, and it was a generally understood thing that if our men waited the enemy in the open, an attack would certainly be made upon them. It was foreseen that this attack would be an enveloping one made from all directions, and that consequently front must be showed to every point of the compass. There was no regular convoy to be defended, but a certain number of ammunition and tool carts had to accompany the force, and these must be protected. A safe place must also be arranged for the hospital. It was evident, therefore, that our men must form a hollow square of some sort, within which the waggons and field hospital could be placed. Let us now see what were the arrangements actually made.

The whole of the Infantry was drawn up in a large hollow square —two deep—with the guns equally divided among the faces. A reserve of about two companies per face was kept inside the square, the whole of the natives being also placed within it. The mounted men were sent out on every side to meet the enemy, with orders to engage him, but retire, when pressed, into the square. The whole of these arrangements were carried out without any interference on the part of the enemy, whose men were, however, seen on the slopes of the hills on every side. Gradually, however, the enemy closed in, and soon the mounted men became engaged. Retiring before the Zulus, these slowly fell back upon the Infantry, and as soon as the enemy had advanced within range of the square, the Cavalry were withdrawn into it. The foe then advanced simultaneously on every side upon the square, firing heavily as they came on. On our side fire was opened as soon as the enemy were within good range, and was kept up without intermission during his subsequent advance until he fell back again. This, however, did not occur until he had got in some places to within 60 or 70 yards, but the fire of our men was so heavy that his loss was immense. Once he began to retire the battle was practically over, for he had exhausted his moral force in endeavouring to close. The Cavalry was then let out upon him, and his retreat converted to a rout. In this way, without moving our men a yard from the position they first took up, a decisive defeat was inflicted upon the enemy, and with but little loss to ourselves.

Certainly the battle of Ulundi fulfilled its object, and was cheaply gained; so far the tactics employed justified themselves. But it by no means follows that similar tactics would produce equally good results on another occasion. The more closely we examine the details of that action, the more clearly does it appear that the arrangements made at Ulundi were defective in theory at least. Against the particular foe who had then to be met they answered thoroughly, but they might at least prove dangerous against another enemy.

Five thousand men were crowded into a space of about 150 yards a side, and formed an almost solid square of that extent. It would seem scarcely possible for the worst of marksmen to fail in hitting such a target; but luckily the Zulus were inconceivably bad shots. Even they, however, managed to hit about 140 men, and we can scarcely hope to meet, at least it would be dangerous to trust to meeting, such bad shooting in future. It is true that our savage foes are never likely to be as well armed or trained to the use of arms as our own men, but their superiority of numbers will help them to make up in some measure for their inferiority in these respects.

In connection with this subject I may add a few words about the native ideas of shooting. During the present Basuto war the Colonial forces have been unpleasantly reminded of the natives' immunity from many of the rules which guide civilised soldiers in their method of fighting, by finding themselves exposed to a hot fire from an immense range. Some of them have jumped to the conclusion that the enemy is better armed than our own men, and of course an attempt has been made to make political capital out of the fact. On examination we shall find that the reason of this lies rather in the method of using them than in the arms themselves. Experience has taught the natives two things.

Firstly, that they need not attempt to aim very accurately at the object they wish to hit, for they are not likely to hit it if they do.

Secondly, that the moral effect of a heavy fire, even if it does not do any material damage, is very great against their fellow-savages, the foes they usually meet. Knowing as they do that by maintaining a heavy fire from a great range they are almost as likely to occasion a few casualties as by firing at moderate ranges, for in either case each hit is a fluke, they blaze away at any distance from 1,500 to 2,500 yards. If they use up all their ammunition they can disband or retire, in either case without a decisive victory being scored against them. To this long-range fire our men have no reply save guns and the offensive action of Cavalry. The Infantry dare not waste their rounds by returning the compliment. But neither guns nor Cavalry can be trusted to drive the enemy away to a greater distance than 2,500, especially in broken ground. To offer such a large mark as the Ulundi square to fire of this nature is evidently to expose the men to considerable loss. Against a foe like the Basutos it is not unlikely that a severe lesson would be taught us if we attempted to do so, and in any case it seems dangerous.

If we attempt to apply a square of this sort to even the most level ground, it will be found that the field of fire in some parts of it is greatly curtailed by some slight rise or depression in the surface, or by bushes, rocks, or other cover. Thus at Ulundi, although there was an average field of fire of some 500 or 600 yards round the square, there were places where the Zulus could get very near our men before they came full under fire. Thus it was that opposite the corner guarded by the 21st Royal Scots Fusiliers, the natives arrived within 50 yards of the square and for a few minutes a hand-to-hand struggle seemed imminent. In order to obtain a maximum effect from a given number of rifles the formation of the troops must be made to agree with the features of the ground, and this a rigid square will not do. In places the line must be pushed forward, in others drawn back, and more attention must be paid to the development of the offensive power of the weapon than to the defensive strength of theoretical formations.

By adopting the continuous square formation all power of manœuvring was lost. No arrangements were made for any advance or retreat of any portion of the line. It was, and was intended to be, a stolid defence, a stone wall against which the enemy could dash his head. Is it absolutely necessary to cast away the advantage which the power of manœuvring gives in order to resist a horde of savages? Surely some more pliable formation may be adopted than the Ulundi square.

Cooped up inside the square the Cavalry were powerless during the continuance of the action. Under no conceivable circumstances could they have been employed, unless the square was broken and a hand-to-hand fight ensued. Even in that case their horses would have been but an incumbrance to them, they could not have been used for charging. When at the opening of the fight the mounted men retreated towards the Infantry followed by the Zulus, they had to retire inside the square earlier than need otherwise have been done to clear the front of fire, and also to allow the gap made in the square for their entrance to be closed again. At the end of the battle, when the enemy wavered and was evidently about to retreat, the Cavalry were ordered out to charge and pursue them. There was so much delay, however, in getting them out of the crowded square that comparatively little execution was done by them. No large bodies of the enemy were cut off in their retreat and made to surrender their arms; and, though a certain number of the hindmost stragglers were slain, no decisive results were obtained by this arm of the service.

I think enough has been said to show that the hollow square formation is far from faultless. I began by admitting that a hollow square formation of some sort must have been adopted, but need it have been one of the nature of that actually used? Need it have been an accurately formed geometrical square, or rather oblong? Need the sides have been continuous?

If it was necessary to avoid all intervals in the line, it might still have been possible to have adapted the shape of the square to the configuration of the ground, so as to have improved the field of fire. At the same time it must be remembered that, with the force present, only a limited length of line, two deep, could have been formed. The space enclosed by that length of line was already small, to have broken the line with re-entering and salient angles would have made it smaller. Any great divergence from the straight faces employed was therefore impossible, and it is questionable whether any good would have been done by small alterations.

But is it necessary that the line should be continuous? A great deal has been said and written about the unsteadiness of our young soldiers during the Zulu war, and it is possible that nothing but a close formation, such as that employed, would have answered, but I do not think so. In the majority of instances, however, this is not so. The line may be formed in sections, each section in close order, with considerable intervals between them. To illustrate my meaning I will apply this formation to the force present at the battle of Ulundi.

There were present at that battle, roughly speaking, 3,000 Infantry, 1,000 Cavalry, and 1,000 natives. The Infantry for the purposes of the action might have been divided into five battalions of 600 men each, of which one would have furnished the reserve. The remainder would have formed eight demi-battalions, each occupying a front of about 100 yards. These would be formed on a more or less circular front, with intervals of about 100 yards between the demi-battalions, thus occupying a perimeter of about 1,600 yards, or a square of about 400 yards a side. Within this square the Cavalry would have retired when pressed by the enemy, but the retirement need not have been effected so early; firstly, because they would not have masked the fire of the Infantry behind them to the same extent, owing to the increased front taken up; and secondly, from the removal of the necessity for closing up the gap in the square by which their entrance was effected. The reserve battalion would also be kept in the centre of the square ready to reinforce any portion of the line where their services might be required.

During the continuance of the attack each demi-battalion would be self-supporting, at least for some time, however hard pressed by the enemy. So long as ammunition holds out, experience shows that it is impossible for the enemy to break a force of 300 men who are in close order. But it may be urged that the enemy may penetrate between the demi-battalions, and produce a moral effect highly dangerous to the safety of the whole force. To guard against that we have, firstly, the reserve battalion, which can fill up the intervals at any portion of the line really seriously threatened; secondly, the Cavalry.

With regard to the reserve battalion, it must be remembered that if its services are required at all, they will seldom be so on more than one face at a time. To endanger the safety of the line the enemy must mass against some point in it. If he attack on all sides simultaneously he must be comparatively weak everywhere. In the former case the reserve battalion can be moved to the dangerous side, and be employed as occasion may require. In the latter its services will seldom, or never, be required at all.

But necessary as it may be to keep one battalion in reserve, it is to the Cavalry that the real defence of the intervals must be entrusted. At the battle of Ulundi the large (for the number of men engaged, *very* large) body of mounted men was practically useless during the greater part of the action. They added to the crowd inside the square, increased the number of casualties that occurred, and, had the front line given way anywhere, would have made the ensuing confusion worse than ever. But with such a formation as I have described there would be plenty of sphere left for their action. If the enemy at any time should draw dangerously near the line, a charge delivered with energy through the intervals would almost certainly cause him to fall back. The charge could be delivered, and the Cavalry could return within the square, without masking the Infantry fire (or at least without doing so to any great extent), and without upsetting the formation adopted. Similarly, when the time came for the final charge and pursuit, the Cavalry could be out of the square and upon the enemy without that delay which took away so much from the effectiveness of the pursuit at Ulundi.

The use of Artillery in such actions presents but little difficulty. At the commencement of the battle the guns may be sent out with the Cavalry to annoy the enemy; returning to the position in time to assist in the subsequent defence. The number of guns available will usually be small, consequently one should not expect any great physical result from them. At the same time their moral influence upon most natives is very great, while to our own men the sound of the big guns blazing away by their side is very cheering. At the same time guns are frequently of great use in counteracting the long-range fire of the enemy, and were it for this reason alone their presence cannot be dispensed with.

Field works on the field of battle are usually intended solely to protect the men who occupy them from the enemy's fires. Time will seldom admit of any strong profile being given to them, and consequently as a barrier to the advance of the foe their value is almost *nil*. But in our savage wars it is seldom the enemy's fire that has to be feared. Consequently the construction of shelter trenches and similar works, for which alone there is usually time available, cannot be regarded as a necessity. At the same time a few men's lives may be saved by them, and, therefore, it would always be well to construct them where possible. More especially is this the case with the field hospital. This is usually placed somewhere about the centre of the space enclosed by our men, and like every inch of that space it must be exposed to the enemy's fire. If time does not admit of the hospital being surrounded with a good wall before the fight begins, it is always possible for the reserve to continue the work during the progress of the combat.

The importance of clearing away all cover from the immediate front cannot be exaggerated. On the efficacy of our fire must our safety in great measure depend. It is by shooting down the enemy fast enough that a moral impression will be made upon him strong enough to make him forget his superiority of numbers. At Ulundi a small patch of low bushes about 70 yards from the left rear face of the square was occupied by a few of the enemy who maintained their ground there till the very end, and who killed and wounded several of our men notwithstanding the heavy fire brought to bear upon them.

There is one point more connected with the battle of Ulundi which deserves notice. The whole of the natives with the army were placed *inside* the square. It was felt that it would be eminently unsafe to place them in line with the other troops, as they would almost certainly have broken and destroyed the formation. It may be asked then what was the use of having these men with us?

The sad experience of Isandhlwana has shown us how unsafe it is to trust the defence of any portion of the line to inferior troops in cases where the issue of the battle is likely to be at all doubtful. If in the front line they will break, if in reserve they will disappear, at the very moment when their assistance is most needed. The use of friendly natives, however well armed, as troops of the line, must always be attempted with caution, frequently it must be given up altogether. But even where it is determined to do without their aid as fighting troops, it will usually be found that they are very valuable auxiliaries in other respects. More especially on outpost duty will they be found of use, where their good eyesight, and knowledge of the enemy and the country, will frequently be of the utmost service. There seems to be some freemasonry or instinct among them by which they can scent danger from afar, and warn the white man of the proximity of an ambuscade into which, but for their assistance, he would most undoubtedly have fallen.

The best method of utilising their services as picquets is a matter of some dispute. On the whole, I believe that it would be better to attach a few natives to each picquet to be used in conjunction with the Europeans posted as sentries, rather than to put them out as separate picquets. In the latter case it is not impossible that the whole picquet may vanish on the approach of danger without giving any warning at all. In this, as in all other cases, where the services of natives are to be used, the rule must be, 'use, but do not trust them.'

I have now gone over—very imperfectly no doubt, but still I have gone over—the various points I had set myself in commencing this essay. It only remains to record my reason for choosing as my motto 'Serrez les rangs.' At the commencement of the Zulu war the necessity for close order does not seem to have been recognised. The experience of the Old Colony War had led our men to despise their enemy. They never expected him to close with them, and for the purposes of a fire-fight *only* the wider the front occupied the better. It diminished the chances of being turned or surrounded. Isandhlwana came as a rude awakening from this dream of security. It is true that the old tactics were successful at Zunguin Nek and Inyezane. But the fact remained that the Zulus *meant* to close when they advanced to the attack, and Isandhlwana proved that under certain circumstances our fire would not stop them. It became, therefore, necessary to prepare, not merely to use our firearms upon foes at long range, but also to beat off the enemy when he came in overwhelming numbers to assegai distance. Now, one man surrounded by four or five Zulus stood little or no chance, but 100 men together might well beat off the assault of 400 or 500. In close order our men would be safe, and yet they might draw every advantage from their weapons. So far, I feel that everyone must agree, and against a foe, our superior in numbers, our equal in pluck, we must 'serrez les rangs.'

But having agreed to this, I must take leave to differ from those who think it also necessary to close up the line of battle. I believe that it is possible still to fight on an extended front, but to do so the men must not be in individual order. Divide the line into sections, each capable of independent defence, each kept in close order, and then, more especially if we have a fair amount of Cavalry available, we may extend the front by leaving intervals between these sections. It is in close order for the individual soldier, but open order for the tactical units, that I believe the true solution of the problem of savage warfare will be found.

R. DA C. P.

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PLATE I.

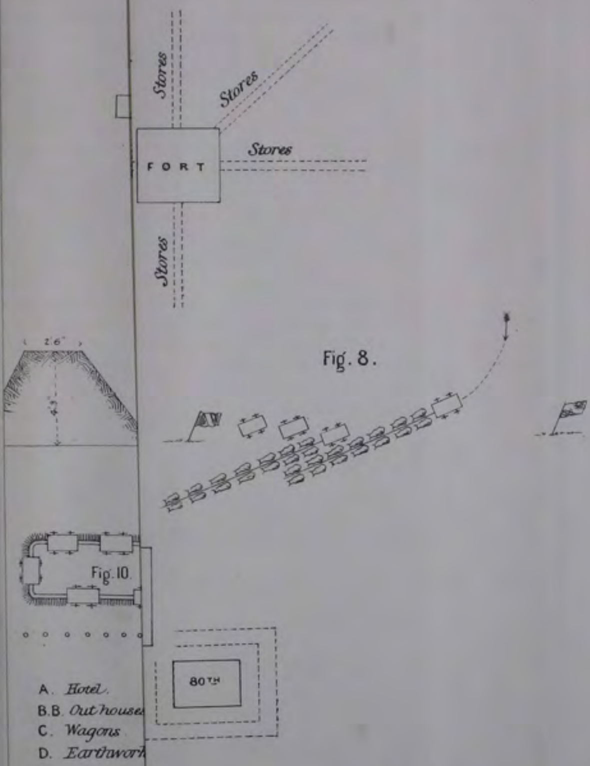

Fig. 8.

Fig. 10.