R·E

PROFESSIONAL PAPERS

OF THE

CORPS OF ROYAL ENGINEERS.

EDITED BY

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ROYAL ENGINEERS INSTITUTE.

OCCASIONAL PAPERS.

VOL. XIII.
1887.

Chatham:
PRINTED BY W. & J. MACKAY & CO., 176, HIGH STREET.
PUBLISHED BY THE ROYAL ENGINEERS INSTITUTE, CHATHAM.

AGENTS: W. & J. MACKAY & CO., CHATHAM.
ALSO SOLD BY HAMILTON, ADAMS, & CO., LONDON.

1888.

PREFACE.

VOL. XIII. of the *R.E. Professional Papers* (Occasional Papers Series), now presented to the Corps, may be said to deal with the past, present, and future of Military Engineering in this country.

Lieut.-Colonel W. G. Ross' paper on the "Sieges of the Civil War," which treats of the past, is of interest not only to the Engineer, but also to the Archæologist and student of history. It supplies an account of the work of the Military Engineer at a critical period; information which could hitherto only be obtained by a most laborious examination of old histories and State documents, but which, thanks to the research of the compiler, is now placed in a concise form before our readers.

Major J. F. Lewis contributes a paper on "Types of Works for Coast Defence," which gives the latest ideas on a subject that is now occupying the attention, not only of our own officers, but also of all interested in the prosperity of the commerce of our nation.

Captain L. Jackson's paper, written with a view to promoting discussion on the present and future methods of fortification, will, it is hoped, produce the required result, and promote friendly discussion on the all-important question, both to the Corps and to the Country, of the best method of fortification at the present time and in the future, due regard being had to economy. It is proposed to publish any discussion that may be received on the subject in the *R.E. Journal*, so that it may be kept up from month to month, and finally to reprint a digest of the results arrived at in the *Professional Papers*.

Major G. S. Clarke, C.M.G., again gives us a *précis* of the "Lydd Experiments," which will be of great value to officers engaged in fortification work, and will give them some idea of the effect the latest developments in artillery science will have upon their work, and guide them so to arrange their designs as to reduce this effect to a minimum.

Colonel Holdich's paper on "Surveying" gives a graphic account of the difficulties a surveyor may expect to meet with in the field, and demonstrates that the high-road to success consists not only of a knowledge of the various methods of work, which can be acquired by instruction, but also of the art of so combining them together as to produce the greatest probability of success. This end can only be gained by practical experience, and the description he gives of the difficulties met with in actual work will, undoubtedly, be of great use to surveyors unaccustomed to work in a new country.

Mr. Conder, in his lecture on the "Purification of Sewage by the Iron System," brings under notice a process which, if it will answer the rough test of every-day use as well as it does in the experiments in the laboratory, promises to be one of great value. The use of copperas as a disinfectant has long been known, but its employment as a disintegrator of sewage is new, and we believe is the first really chemical process for decomposition, the others, or at any rate most of the other so-called chemical processes, consisting merely of mechanical precipitation. This paper has already attracted considerable attention, the extra copies printed in pamphlet form being disposed of to Societies and persons interested in the subject almost as soon as they left the printers' hands.

A paper on "Testing of Coal Gas" we must hold over until our next, as the issue of this volume has already been much delayed by the large number of plates contained in it, and which have taken a long time to reproduce.

FRANCIS J. DAY, MAJOR, R.E.,

Secretary, R.E. Institute, and Editor.

Chatham, November, 1888.

CONTENTS OF VOL. XIII.

LIST OF PLATES.

PAPER I.

TREATMENT OF SEWAGE BY THE IRON PROCESS.

By F. R. Conder, Esq., M. Inst., C.E.

The rapid increase of population in the urban districts of Great Britain renders the accumulation of the refuse products of organic life a source of continually increasing nuisance, cost, and danger. It is true that the quantity of putrescible matter daily produced by each individual is not very large. It amounts to about 46 pounds per annum per unit of population. Nature has provided, not only for the disinfection of this matter, but also for its utilisation, in the great cycle of animal and vegetable life. But it is idle to appeal to the order of nature under the artificial conditions of modern civilization. In a vast province covered with bricks and mortar, those disinfecting powers of earth and water which are available in wilder regions, are inoperative. Earth is a purifier when it is sufficiently dry and comminuted to serve as a storehouse of oxygen. Water requires volume and current to destroy the impurities thrown into its course. Wet earth, and stagnant or salt water, store up organic poison, which is fatal to vegetable as well as animal life.

With the 46 pounds of organic or putrescible matter just mentioned, are naturally associated twenty times that weight of water, as well as 25 pounds, and often much more, of minerals and gases. The 1,000 pounds weight of offensive matter thus constituted is diluted, in what are regarded as our best regulated towns, by about 100 times their weight of water, forming a liquid which in its turn is impure enough to pollute ten times its own volume of running water. Unless, therefore, a proper antidote be in due time applied to the organic poison, the springs, wells, brooks, and rivers of a densely populated district become cradles and carriers of infection; and the neglected products of each human life menace the safety of at least ten human beings.

It is true that in the offensive mixture above described there exist elements of great value for the food of vegetables. Each thousand-pound unit contains ammonia, potash, and phosphates to the theoretic value of between eight and nine shillings. It is perhaps unfortunate that this calculation has been made public; for the result has been that the attention of chemists and inventors has been directed, not to the destruction of the sources of danger, but to making money by the preparation of manure. The number of patents that have been granted for the treatment of sewage is uncounted. In the single year 1872 no fewer than 76 of such patents were applied for, and it is significant to note that the specifications for the same are all enrolled in the Patent Office under the title of Manures.

Counting localities, and also allowing for the successive application of different methods of treatment in the same place, the details of more than 200 trials have been now for some time accessible. We can cite some 80 instances of the application of precipitating processes; about the same number of instances of irrigation; half that number of attempts at filtration; and more than 20 examples of crude discharge into rivers or the sea. How far any of these systems have been crowned with a satisfactory result may be estimated from the very latest efforts of the sanitarian in London and its environs. Tottenham, Chertsey, and other places, are bye words of abomination; and at Hendon the large sum of £90,000 has been expended in providing for the sewage of eleven thousand persons, with the result of creating such an intolerable nuisance as to attract the attention of Parliament.

In London so much money has been spent for merely running the crude sewage into the Thames, twelve miles below London Bridge, that labour and interest on money, in 1886, amounted to 2s. $4\frac{3}{4}$d. per unit of population. And yet so undeveloped are the resources of the sanitarian, or so prohibitive is their cost, that nothing deserving the name of purification is even contemplated. The effluent produced by the process now in course of extension contains more foreign matter per gallon than is found in the raw sewage of Hertfort, Rugby, Croydon, Warwick, or Worthing. The matter removed from it is a semi-fluid of intolerable foulness, and $15\frac{1}{2}$ times the weight of the solids so removed. And this sludge, after being reduced to but little more than a million tons per year by a second subsidence in costly tanks, now in course of erection for the purpose, it is proposed to convey in steam boats down the river, to be discharged in the tideway of the channel. The fact that this mode of proceedure is regarded by many competent judges as that which will prove least burdensome to the ratepayers, is one of great significance as to the unsolved difficulties of the sewage problem.

In the presence of these two latest outcomes of sanitary science it is unnecessary to track the footsteps of those various deputations—from Guildford, Buxton, Hendon, and so many other places—which have visited locality after locality, in the hope of lighting on a satisfactory process, but have returned empty-handed and disappointed. But inasmuch as the process now to be brought under notice differs from all others, not in degree only, but in kind—not only in practice, but in principle—it may be well to summarise briefly what may be called the generic divisions of the methods of treatment now in use.

The first attempt at the disinfection of sewage, after the ordinary house drainage has assumed that condition, has usually been by the agency of running water. When the proportion of population to river-flow will allow, this is probably the best mode of treatment. The magnificent water supply of Imperial Rome so diluted the contents of the *Cloacæ* as to render the effluent harmless as a contribution to the daily flow of the Tiber. But a sharp limit is imposed on river dilution by density of population. We may take it that the presence of three grains of nitrogenous organic matter in a gallon of water renders it not only unfit for drinking, but to some extent polluting as an influent. To obtain even that proportion requires a volume of 290 gallons per day, per unit of population. The population of the great outfall district of the Thames valley, at the date of the census of 1881, was 6,850,000 persons. It will now be understated at 7,000,000. The refuse from this population, if it were all water-borne, would pollute 2,000,000,000 gallons of water daily. But the summer flow from the entire water-shed of the Thames hardly exceeds a third of that volume; and it is in summer that the poison is most active. It is not, therefore, necessary to quote the graphic description given by Lord Bramwell of the state of the lower Thames in a hot summer, to show that the capacity of the river as a purifying agent is already dangerously over-taxed. And although in some instances, where the flow of water is large and swift, as at Newport and at Dundee, running water is yet employed as a purifying agent, it is clear that as a rule the population of Great Britain has advanced beyond that degree of density up to which river agency can be relied on.

Current is essential to the purifying agency of water Volume alone, without current, is inadequate for the purpose. Thus the vast area of Lake Michigan, 23,000 square miles in extent, has not prevented the fouling of the water of the Lake adjoining the city of Chicago, notwithstanding a water service of 108 gallons daily per head for its 503,000 inhabitants. What may be the effect of ocean currents, if a steady supply of sewage is continually poured into the sea at the same spot, we have not the data for deciding. But we do know that the sea water, so to speak, pickles sewage; and prevents, or very materially retards, its oxidisation. "The Bay of Cadiz, Rio di Janeiro, and Havannah are ports said to be now reaping the results of pouring sewage into the sea, continued through ages."—(*Purification of Water-carried Sewage, p. 174*). Hastings, Margate, Ipswich, Edinburgh, Campbelltown, Brighton, Southampton, Cowes, and other places, are suffering from the same cause. And the dangerous condition of the port of Marseilles is such that "it is currently reported among mariners that the Marseilles pilots can take a ship into that port in the thickest of fogs, and the darkest of nights, guided by the smell alone." The disastrous failure which, rather more than four months after the preceding lines were written, has attended on the boating out to sea of the sludge produced by the treatment of the Metropolitan sewage at Barking, is described in the Appendix.

The disinfecting power of earth depends entirely on its agency as a storer and distributor of oxygen. When earth is brought into the house as a disinfectant, 200 times the weight of the organic matter to be oxidised is used. And in that case a separate system of drainage has to be provided for the liquid refuse, which contains more than four-fifths of all the putrescible matter derived from human sources, and which is more refractory to treatment than ordinary sewage. Apart from the double expense thus involved, the supply and removal of such large quantities of earth are impracticable in a great town.

When sewage is taken to the land, the difficulty is but little diminished. The activity of the oxidising action depends on the state of the weather. When land is frozen or wet, even when not actually flooded, its action as a carrier of oxygen is in abeyance. The area required for sewage irrigation is so large in proportion to population as often to be impossible of attainment. In 32 cases tabulated by Messrs. Robinson and Mellis, (*Purification of Water-carried Sewage, p. 32*), nearly two poles per individual have been needed. It is only dilute sewage that can be safely turned over land without being subjected to some previous chemical process. In seven towns in which organic matter in suspension has been almost entirely removed (in fine weather) from the effluent by irrigation, the total amount of solid matter so removed has been only 15·13 grains per gallon, or 24 per cent. of that contained in the sewage. The Craigentinny meadows near Edinburgh are irrigated with the strong sewage of that city to a depth of about one inch per day. "The result has been a yield of heavy grass crops, but the meadows are described as being in a most insanitary condition." "The water," say the Rivers Pollution Commissioners, (*1st Report, 1862, pp. 74–95.*) "leaves the grass land still filthy and offensive." The effluent, after passing over the land, still contains 5·82 grains of suspended organic matter per gallon. The amount removed from the effluent in this case is 39·1 pounds of organic matter per acre, per day, which is about four times as much as the average in the seven cases before cited. During flood time the sewage escapes raw into the sea.

Attempts at filtration are now by almost universal consent abandoned. When combined with the earth closet system the failure has been conspicuous, as in the case of Chichester barracks. "Though many trials have been made, no instance can be adduced of a successful attempt to purify crude sewage by filtration alone." "Excepting in laboratory experiments, and a few instances upon a very small scale, filtration of crude or untreated sewage, apart from irrigation, has never yet succeded."—(*Purification of Water-carried Sewage, p. 163*).

There remain the resources of chemistry. But to the present time, with the exception of the IRON PROCESS, chemistry has nowhere been applied to in order to destroy the putrescible contents of sewage. Differing in detail, all the chemical processes now in use agree in being methods of precipitation; lime, alumina, and other materials being employed, not to purify, but to clarify, sewage. Precipitants are, in fact, only intended to hasten a subsidence which would take place more effectually without their agency, if enough time could be allowed. They drag down the suspended matter, and at the same time often increase the proportion of matter held in solution. Their action might be characterised as mechanical, rather than chemical, were it not that at a certain stage of the process a most objectionable chemical action invariably takes place. This is the formation of "sludge," which is a semi-fluid containing the putrescible matter precipated from the sewage, together with the inorganic matter and the precipitant, and from 85 to 97 per cent. of water; the removal of which is a difficult and costly process. "It has been erroneously assumed that the foul semi-fluid called sludge is a necessary product of the treatment of sewage. Such an assumption is entirely opposed to fact." (*Minutes of Proceedings of Institution of Civil Engineers, vol. 88, p. 273*).

"To enumerate the various methods proposed from time to time for separating the sludge from the liquid sewage," says Mr. Dibdin, the Chemist to the Metropolitan Board of Works (*same volume, p. 160*), "would require more time and patience than the recital would be worth when done. The first consideration in connexion with the disposal of sewage sludge is its bulk. This is largely composed of water, which varies from 90 to 97 per cent. Of this quantity a considerable portion can be separated by allowing the sludge to settle in tanks, specially contrived for the purpose, in which the slimy matter can be placed to a depth of from 12 to 15 feet. On standing for some time the slimy matter will be found to form a stratum, about one third below the top of the water. The top water can then be drawn off, and returned to the sewage for treatment." By this second settlement in special tanks, the amount of water associated in the sludge produced at Barking is so far reduced that instead of being 15½ times the bulk of the solid matter removed from the sewage, the mass is only little more than nine times that bulk. For the north side of London alone these tanks will cost £406,000.

Serious as is the cost involved by the bulk and weight of this product of precipitation, the condition of the mass is a yet graver source of mischief. "A cubic yard of sludge weighs practically 16 cwt., and it consists of one part of organic and mineral matter, and nine parts of strong sewage," (*same volume, p. 167*). All the putrescible matter removed from the sewage by precipation is stored up in the sludge, the quantity of which ranges from 16·6 to 30 cwt. per 1,000 persons daily. In the disposal of this product lies the chief difficulty in the treatment of sewage; and it is becoming more and more generally suspected that the destruction of the mixture by fire, a costly and offensive process, is the only procedure that can be thought to fulfil the requirements of public health.

At the allowance of 10,000 gallons per individual per annum, a gallon of ordinary sewage contains, theoretically, 32·5 grains of organic, and 17·5 grains of inorganic, matter. In addition to this, the water as supplied for consumption usually contains at least 20 grains of mineral matter in solution. If to this we add 20 per cent. on the two first figures as an allowance for the refuse from cooking, washing, and the like, we have a total of 84 grains of foreign matter per gallon. The average of 24 analyses, chiefly taken from the reports of the Rivers Pollution Commissioners, is 81·86 grains per gallon; that of 93 samples taken by Messrs. Lawes and Gilbert, 87·5 grains per gallon; that of the sewage of London, 93·89, according to Dr. Letheby; but as it arrives at Barking it is given by Mr. Dibdin at 87 grains per gallon. 31·5 per cent. of the foreign matter, according to Messrs. Lawes and Gilbert; 40 per cent., according to Mr. Dibdin; 38·7 per cent., according to theory, is organic; half of it according to Messrs. Lawes and Gilbert; half of it, according to the analyses at Chichester; and 31 per cent. according to Mr. Dibdin, is in suspension; the remainder in solution. These figures indicate either the deposit of a considerable quantity of the solid contents of the sewage in the 250 miles of the London main drains, or the conversion of a proportionate quantity of suspended matter into a state of solution during a long run, accompanied by much pumping. Comparison with the analysis by Dr. Letheby gives four grains thus dissolved, and seven grains precipitated, per gallon, or 70 tons of sludge per day deposited in the main and intercepting sewers.

The difference in the effect of various methods of treatment appears to depend more on the strength of the sewage treated, than on any other assignable cause. Thus, from the sewage of six towns, an average gallon of which contains 134 grains of foreign matter, 49 per cent. is removed by various methods. But in the case of five towns, with a sewage of the average strength of only 42·34 grains in the gallon, only 6·3 per cent. is removed. And in two of these towns the effluent contains actually 7·5 per cent. more solid matter than the untreated sewage.

Again as to method. Precipitation removes 41·6 per cent. from the sewage of 12 towns, of an average strength of 102·22 grains per gallon, but leaves 59·96 grains, of which 1·57 are of suspended organic matter, in the effluent. Irrigation removes only 24 per cent. from the sewage of seven towns, with an average strength of 67·62 grains per gallon; but of the 50·08 grains left in the effluent, only 0·75 grain is suspended organic matter.

These figures bear out the conclusion of the Local Government Board, as to the necessity of subjecting the effluent from any precipitating process now in common use to a passage through land. But the double process, as in the cases of Windsor and of Hendon, is attended with double expense; and not unfrequently the irrigating process loads the effluents with salts washed from the soil. On the other hand, land fails, even in dry weather, to extract more than a given and sharply limited percentage of matter from a strong sewage.

In the 24 towns above cited only 34·4 per cent. of the total foreign matter present in the sewage has been extracted by various processes, leaving 52·77 grains in each gallon of the effluent. This is twice the strength of the sewage of Hertford, which has caused intolerable nuisance when turned into the river Lee. The sewage of Edmonton, after undergoing a double process, visibly and sensibly fouls that river. Allowing 20 of the above-mentioned 52·77 grains to be naturally present in the water, we still find 32·77 grains derived from sewage in the effluents thus produced. To call such an effluent pure, is an abuse of language. It is, indeed, said, that purity of effluent is a simple question of expense. But when we find that the expense has risen as high as £76 6s. per million gallons, it is obvious that no practical value attaches to such a statement. And the purer the effluent, the larger is the amount of polluting matter which the precipitating processes now in use store up to putrefy in the sludge.

The cost of the various methods according to which sewage is now disposed of varies very greatly, according to local conditions. It is stated in different ways :—as a gross sum; as a cost per million gallons; and as an annual cost in the pound of rateable value. It may be most convenient to accept the common measure of annual charge per unit of population, including both working cost and interest of money. Thus regarded, it ranges from one shilling per inhabitant at Brighton, for merely running it into the sea, to 3s. 5d. per head at Birmingham, for a mixture of the pail system, the lime process, and passing the effluent through land. The cost of the pail system at Manchester raises the annual expenditure of the Health Committee, according to a statement made in the transactions of the Manchester Statistical Society, session 1885-86, to 5·19 shillings per unit of population. For London, the cost of doing little more than turning the raw sewage into the Thames, 12 miles below London Bridge, in the year 1886, amounted to 2s. $4\frac{3}{4}$d.

per inhabitant. The cost of intermittent filtration, at Merthyr Tydfil, under unusually favourable conditions, and exclusive of supervision, was 1s. 10¼d. per inhabitant in 1876. The average cost of the irrigation process in 24 towns has risen in ten years from 1s. 10½d. to 4s. 3d. per unit. Precipitation works are said to have been carried out for 1s. 2·4d. per unit; but information is wanting both as to the character of the effluent, and as to the detail of cost. The question of the disposal of the sludge formed by precipitation is everywhere becoming more and more serious.

The cost of sewage treatment is everywhere on the increase. This is due to two causes. One is the steady increase in the cost of almost all public works (with the exception of gas works, where scientific improvement is as yet unexhausted), in proportion to the increase in the density of the population. Thus the rateable value per head in London was £3·08 in 1841, £6·09 in 1871, and £7·22 in 1881. Over all England, with the exception of London, the rateable value per unit of population rose from £4·74 in 1871 to £5·05 in 1881. The other cause is that in processes which, like those now in ordinary use, may mitigate nuisance, but do not attempt its destruction, the evil is almost everywhere gaining on the remedy. This is especially the case with regard to the action of land. The land and works for the treatment of sewage cost £4·17 per inhabitant at Windsor, £7·2 per inhabitant in the Wandle valley, and £8·17 per inhabitant at Hendon; the last-named works being only finished during the year 1887.

The subjoined table shows the minimum and maximum cost of the capital outlay on works and land for the treatment of sewage, under ordinary conditions (interest being calculated at 5 per cent.) per unit of population:—

	House drains, cesspools, or street drains, included in rent.	Capital Charge.		Annual Charge.	
		Min.	Max.	Min.	Max.
		£	£	s.	s.
1	Main drains.... ...	0·50	2·5	0·50	2·5
2	Outfall works.	0·33	1·6	0·33	1·6
3	Steam power... ...	0·25	0 5	0·25	0·5
4	Land and preparation. ...	1·00	2·6	1·00	9·6
	Approximate total ...	£2·08	£7·2	2·0s.	7·2s.

Almost the lowest cost of annual working is that given by Sir J. W. Bazalgette, for merely turning the sewage into the Thames, which he put, for the year 1883, at 6d. per unit of population. For 1885, however, this rose to 7·3d. per unit; and for 1886 to 10·45d. per unit, with the prospect of considerable increase. Taking the allowance of 5 per cent. for interest and sinking fund, which is made in the report of the Metropolitan Board of Works for 1886, the cost of this extremely inefficient service for that year amounted in all to 2s. 4¾d. per unit of population. The actual cost of typical cases of treatment now in operation is given in a table in the Appendix. The annual outlay ranges from a minimum of 1s. 10¼d., to a maximum of 5s. 8d., per contributory unit of population.

The results of the IRON PROCESS differ from those effected by any other method of treatment, in the same way that the cure of a disease differs from the mitigation of its severity. The distinction is not merely specific, but generic. The putrescible matter in the sewage is not stored up in the precipitate, but is destroyed as a chemical compound. When the iron solution is applied in the chamber or the closet, the effect is immediate, and unpleasant smell entirely ceases. Were such an application made in every house, the sewage problem would be solved. The effect of household treatment, says Mr. Dibdin, (*Minutes of Proceedings of Institution of Civil Engineers, vol, 88, p. 268*), "would be marvellous. No sewer gases either in house or street, the arrival of the sewage at the point of disposal in a harmless condition, and undoubted benefit to those engaged in or upon the lines of sewers." As regards this last feature of the case, the 2nd Report from the Committee on the Ventilation of the Houses of Parliament calls the low level Metropolitan sewer "a long sluggish sewage ditch. In it deposit is always taking place; this is periodically removed by men with scoops and buckets, and from the surface of the sewage itself a very large quantity of gas is emitted. The gases overflow, or are forced out, as the body of water increases, into the adjacent sewers, and escape into streets and houses." It is found that in the Metropolitan sewers, (*Drainage of Lands, Towns and Building, new edition, p. 202*), "it is utterly impossible to remove the accumulations which are liable to occur within them by any other means than cleaning by hand, and thus some £10,000 has been annually spent in London alone, in an employment of a most disgusting and dangerous nature." The cost of this cleansing in 1886 was £13,600; or 48 per cent. of the ordinary cost, exclusive of pumping. Neither the works in progress at Barking, nor those lately completed in the Palace of Westminister, at a cost of £13,265, in any way attempt to remedy this serious source of cost and danger; the annihilation of which is an incident, or bye product, of the IRON PROCESS.

It is well known that salts of iron have a powerful effect as disinfectants. Metallic iron is to a certain extent soluble in water, and its effect in this state is remarkable. Thirty years ago Dr. Medlock and Mr. Quick made experiments on the treatment of Thames water by iron. The water of the river at Battersea was left in contact with iron wire and plates in a large tank for 24 hours, and the improvement in quality was very marked. For many years Mr. Gustav Bischof has advocated the use of spongy or finely divided iron, as a medium for the filtration of water. In 1879 spongy iron filters, on a large scale, were applied to purify the water of the river Nethe for the supply of the city of Antwerp. In 1885, Mr. Anderson, C.E., carrying out a suggestion of Sir Frederic Abel, introduced revolving cylinders containing iron borings, through which the water passed at the intake, in the Antwerp water works. The result was the purification of the water to a considerable degree by the absorption of from 0·1 to 0·176 grains of metallic iron per gallon. The per-chloride of iron affords a very clear permanent solution, but is objectionable, not only on account of its great expense, but also by reason of its bad effect on the effluent. It is stated that the presence of 0·0008 per cent. of chlorine in river water will kill trout and salmon, and that 0·005 per cent. of chloride of lime will kill tench. As to the protosalts of iron, Mr. Bischof states (*Minutes of Proceedings of Institution of Civil Engineers, vol. 72, p. 67*) that "chemistry could not deal with ferrous compounds; they were by far too rapidly oxidised, and they could only be obtained if formed in the filter itself during filtration."

By the method of treatment now applied this difficulty in dealing with the protosalts of iron is removed, and a permanent and stable solution of iron is produced from the sulphate. This is, according to the means used, either a clear black liquid, a clear brown liquid resembling sherry, or a colourless and bright liquid, equally charged with iron. It is thus made possible to apply the exact dose of iron required under any circumstances. When sewage is thus treated, in definite proportions, the putrescible or putrescent matter that it contains is immediately split up into its innocuous elements; the liberation of gas ceases; and the mineral matter, thus set free, subsides as a fine black silt, that is easily swept along by a current of half-a-mile per hour.

Without attempting to enter into the details of chemical affinities, it may be observed that the iron thus applied has a two-fold action. It serves as a carrier of oxygen ; four units of which are combined in the sulphate with one unit of iron and one of sulphur. The remarkable way in which iron alternately assumes the ferrous and the ferric state is well known, and is fully illustrated in the iron process of purification. But apart from oxidisation, iron has a very powerful effect on insect life. "Iron is the only substance known at the present time, applicable to water, that will destroy the known forms of bacterial life."—(*Minutes of Proceedings of Institution of Civil Engineers, vol. 72, p. 48*). Mr. Wynter Blythe, in a communication to the Royal Society, dated 18th October, 1885, shows that the action of ferrous sulphate in destroying micro-organisms is more effective than that of ferric per-chloride, of chloride of zinc, of phenol, or of creosol. Mr. Ogston (*Minutes of Proceedings of Institution of Civil Engineers, vol. 81, p. 294*) found that, in four cases out of five, the treating of water with iron completely sterilized it. Insects by no means of microscopic size, such as the aphides that infest the rose, if placed on a plate of iron are at once paralysed, and within 24 hours turn brown and shrivel up as if burnt. The production of a stable and permanent solution of iron, or its protosalts, thus places in the hands of the sanitary engineer a new resource, and one of a power which it is difficult to exaggerate.

The IRON PROCESS, as now at work, has been based entirely upon experiment. The success obtained at Antwerp, and the partial success obtained at Buxton, by the employment of a natural chalybeate water, led to the institution of a series of experiments, made, in the first instance, on excrementitious matter, both solid and liquid. The results were so striking as to justify the application for a patent, under protection of which trials could be made on a larger scale. A strong domestic sewage, from which rainfall and laundry drainage were excluded, which was stored in tanks for garden use, was found to be especially convenient for analysis, as having a regularity of strength which is not found in the sewers. Experiments were made with iron and its salts, controlled by parallel experiments with per-manganate of potash, which gave results that, although verified by an independent chemist, were received with incredulity. "I hope" wrote a manufacturing chemist, "that you are not thinking of applying sulphate of iron to the purification of water, because of its injurious after effects." "This certainly" wrote another chemical authority, who was pleased to be ironical, "is a discovery of a marvellous property possessed by the chemicals employed, a property entirely overlooked by the numerous chemists who have investigated the action of salts of iron on sewage waters." A third chemist wrote in the same tone as to "the wonderful discovery made by Mr. Conder, that small quantities of ferrous sulphate produce marvellous effects upon sewage, and it would appear that all those who are now labouring in this field of research may cease to work, and consider the great problem as completely solved by that gentleman."

As in most cases where research is patiently pursued, light dawned, in the course of the investigation, from unexpected sources. The absolute failure of the iron, on one occasion, to work as it had been in the habit of doing, led to the discovery that there was a great difference in the dissolving power exerted in light and in darkness. Another casual observation led to the recognition of the effects of slow and continual agitation. When this much of the ground had been cleared, the Borough Surveyor of Guildford saw enough to induce him to facilitate the trial of the process in the sewers of that town.

According to the report of the Borough Surveyor of Guildford, Mr. Henry Peak, a 10-gallon tank was fixed in Bury Street, and supplied with water from the town waterworks, at the rate of about 15 gallons per hour. The disinfectant was placed in this tank, and an overflow pipe was led from it into the adjacent sewer. (See *Fig.* 1, *Plate* I.). The rate of solution was about 1,400 grains of sulphate per hour. The apparatus was set at work at 2.40 p.m., on November 18th, 1885. It was anticipated that several days would elapse before any decided change took place in the purity of the sewage; and samples were ordered to be taken at the outflow every 12 hours. On the 19th November, about 10 a.m., on going into the rude laboratory employed, a bottle of perfectly clear water attracted attention. On being asked what it was, the attendant replied it was the sample taken that morning. Mr. Peak was immediately called, and to the surprise of all present a clear stream, free from any taint, was seen issuing from the outfall; and the smell at the outfall and at the two gullies mentioned in par. 17 of Mr. Peak's report, which had been extremely offensive, had ceased.

Another trial was made, as mentioned by Mr. Peak, on a thousand feet of 15 inch sewer pipe near Dapdune wharf. The arrangements were at first made for the solution of the disinfectant in the sewer itself, with the view of obtaining an automatic regulation of the quantity of iron dissolved, by the varying depth of the flow of sewage. (See *Figs.* 2 & 3, *Plate* I.). It proved, however, that the solution was so much too rapid when the disinfectant was suspended in the current, that the original plan of a separate dissolving tank, in which the sulphate was now placed in a pierced porcelain cylinder, was again adopted. A special provision was made for regulating at will the depth of the water in the dissolving tank, as the rate of solution was found to be accurately determined by the depth of the immersion of the cylinder.

The sewage in the Dapdune drain proved to be extraordinarily foul. Two inspection pits had been sunk; one to contain the apparatus, the other, some 800 feet lower down, in order to observe the result; as the outflow into the river Wey took place under water (See *Fig.* 4, *Plate* I.). A strong dose of iron was applied in the first instance. After the process had been at work about half-an-hour, the sewage at the lower inspection pit had lost its smell, but appeared to the eye fouler than before. It continued to look worse and worse, until the whole surface of the flow was covered with foul floating matter. This went on for about a couple of hours, after which the surface gradually cleared. At the expiration of three hours from the commencement of the trial the flow was a thick brown liquid, without smell, and clear on the surface. A sample, when drawn, was very thick, but immediately began to clear, precipitating solid matter to the amount of about ten per cent. of the total volume of the sample. On a subsequent day the Corporation visited the spot, and took samples, some of which have been kept by members of the Council to the present time, and are perfectly sweet and clear. The sample which was taken at 7 a.m. on the day after the process was commenced was as clear as spring water.

It should be explained that the increase in the foulness of the flow which occurred when the process was first set to work was found to be due to the loosening of the solid matter which, during a period of months, or perhaps years, had formed a coating on the inside of the sewer pipe. Thus the first apparent action of the iron was the cleansing of the drain.

The following extracts from the report by Mr. Henry Peak, Surveyor to the Guildford Urban Sanitary Authority, give interesting information as regards cost :—

"I have made an approximate estimate of the yearly cost of applying the process to the drain at Dapdune, taking the results as obtainable from the experiments thereat as a basis, and I find it would be £17 2s. 2¼d., and as there are, say, ten principal drains equally needing treatment, the cost of similarly treating the whole would therefore be £171 1s. 10½d. per annum.

"To the before-named amount would have to be added the first cost of apparatus, connections, etc., (say, £70 to £100), and the fees payable to the Patentee of the process."

Another trial was made in May, 1886, on the estate of the Carpenter's Company at Stratford-at-Bow. The estate is covered with houses, and has been carefully sewered. Inspection pits, provided with ventilating flues, passing through trays of charcoal, have been formed at distances of 80 yards apart. The water supply is constant, but the consumption is only at the rate of about 10 gallons per individual daily, so that the sewage is more than three times as strong as ordinary London sewage. A tank fitted with a dissolving cylinder was erected and connected with the sewer at the top of Blyth Street, and set to work on the 22nd May, 1886. (See *Fig.* 5, *Plate* I.). On the following day the Superintendent of the Carpenter's Hall Estate, Mr. W. F. Strong, reported as follows:—

"I succeeded yesterday in obtaining a very clear and pure effluent after 12 hour's treatment. I am exceedingly pleased with the result, as the sample of untreated sewage, taken at our very worst time (at 9 a.m.), was very foul indeed. The first samples, taken at 12 noon, and 3 o'clock in the afternoon, show an overdose of iron. By carefully reducing the quantity (the same flow going on) the 6 o'clock sample was clearer, and very little trace of floating iron. The 9 o'clock, and final sample, was all that could be desired, being almost perfectly clear, and entirely free from smell.' Blyth Street was kept perfectly free from smell during the subsequent hot weather, while the smell from the ventilators in the other streets on the estate was overpoweringly offensive.

The sanction of the Secretary of State for War was obtained to the process being tried at the Barracks at Chichester. In these, as in other establishments of the same kind, earth closets have been provided for the use of the men, and the liquid sullage was passed through a filter bed. This method, moreover, removes rather less than one-sixth of the organic matter from the sewage, while the five-sixths which remain, being in solution, are more refractory to treatment than is the case with ordinary sewage. The filter bed, after being in operation for a few months, becomes a source of intolerable pollution. The sewage of Chichester Barracks runs into a 15-inch pipe, which, on leaving the barrack yard, falls 12 feet 3 inches in a distance of 680 feet; and discharges its contents into an open ditch; which, in consequence, had become so foul that the local authorities had taken proceedings against the War Department to compel them to abate the nuisance. (See *Figs.* 1 and 2, *Plate* II.). About half-way down this sewer are placed a ventilating pipe and two road gullies. The smell at these points, and at the outfall of the sewer, was extremely offensive to all persons passing along the road. The ordinary population of the barracks is stated at about 500 men, women, and children; in addition to which two battalions of Militia are encamped in the drill-field during the month of July. The flow from the sewer pipe was gauged on the 12th February, 1886, at 15,000 gallons a day, rather more than half of which was subsoil water; from 6,000 to 10,000 gallons being pumped for the supply of the barracks. An analysis made by the chemist of the War Department showed that with this flow there were 15·62 grains of organic, and 27·96 grains of inorganic matter in each gallon of sewage, which is equivalent to a strength of 46 grains of organic, and 43 grains of inorganic matter in the gallon when the flow is reduced, as it was in the drought of the summer of 1887, to about 10 gallons per individual daily.

The apparatus was set to work on 7th July, 1886, and has been in uninterrupted operation ever since, with the exception of three stoppages for experiment. Within 24 hours the smell at the ventilator, the gullies, and the outfall had ceased. Samples of the effluent were taken by the War Department for analysis on the 17th August, 1886. After the addition of nine grains of precipitant, the effluent was found to contain solids to the amount of 27·86 grains per gallon. Of this only 0·63 grains was organic, and 2·87 grains inorganic matter in suspension; and at least 20 grains per gallon existed in the water, independent of any sewage pollution. There was a disturbance of the effluent in September, due to the clearing out of the old filter bed and pipes by the action of the iron, as in the case of the Dapdune sewer; but the War Department analyses, taken in October and November, 1886, gave a total of only 26·55 grains of foreign matter per gallon in the effluent, of which, at the outside, not more than 6·55 grains could be derived from sewage and precipitant. In fact, there is less foreign matter in the effluent than is contained in the deep well-water of the Kent Water Company.

It was found impracticable to put in the subsidence drain proposed by the Patentee at the mouth of the sewer, owing to the landowners refusing to give permission to do so. The precipitate from the process was therefore swept into the ditch. The Royal Engineer Department put a tub at the mouth of the sewer, with a view of ascertaining the actual quantity of deposit, but its specific gravity is so close upon that of water itself that no reliable data were thus obtained. As taken in the catch-tub, the deposit (which, like London clay, is black when wet, and dries into a brown dust) has a slight smell, due to its containing, by analysis, from 0·48 to 0·60 per cent. of ammonia. But, as taken from the bottom of the ditch, where it has been subjected to the flow of the effluent, the deposit is absolutely without smell. After the process had been for some weeks at work, a transparent gelatinous substance was found deposited on some large pebbles a little way below the outfall. The substance, which had no smell, dried in the air into a fine brown dust, resembling the ordinary deposit in all respects, excepting that it was finer in grain. Further analysis was prevented by the disappearance of the substance, none of which has been found in 1887.

As the Chichester sewage, when most diluted, contains 15·62 grains of organic and volatile matter per gallon, while only 3·92 grains were to be found in a gallon of the effluent, it was expected that the 11·70 grains removed would be found in the precipitate, which would give it a high value as manure, accompanied by a strong smell. According to the analysis of the deposit, however, only 3·29 grains of volatile and organic matter were found in the corresponding quantity of deposit when taken from the catch-tub, showing a loss, or resolution into its innocuous elements, of 53·8 per cent. of the organic and volatile matter contained in the sewage. As there is no smell whatever from the deposit taken from the ditch, it is evident that it cannot contain much nitrogenous organic matter. The total weight of the precipitate, therefore, is considerably less than that of the solids removed from the sewage. It has no disposition to associate with water, and to form a "sludge." It dries in the air, without expense or nuisance, to a fine brown powder, which is only from one-eighth to one-fifteenth of the weight of the sludge produced, by any precipitating process, in the removal of an equal quantity of solid matter from sewage.

The following table shows:—

(1) *Standard of Purity* required by fifth report of Rivers Pollution Commission (maximum proportion allowed).

(2) *Analysis of Effluents* produced at Hertford (by lime process), and at Rugby, Croydon, Warwick, and Worthing (by irrigation).

(3) *Effluent* produced at Chichester by the *Iron Process* according to the analysis of the Chemist of the War Department. The analysis of the sewage was made in February, and that of the effluent in August, so that the real reduction effected by the process was much larger than at first sight would appear.

Comparative Table.

	(1) River Poll. Standard.	(2) Mean of Five Towns.	(3) CHICHESTER.
Period of treatment	6 hours	12 hours	**4 minutes**
Left in Effluent:—			
IN SUSPENSION.	Grains	per	gallon
Dry organic matter	0·7	Max. ·36	0·7
Dry mineral matter	2·1	Max. ·88	0·75
IN SOLUTION.			
Organic carbon...	1·4	1·27	0·14
Organic nitrogen (taken as ammonia)	0·255	0·270	0·05
Metal (except calcium, magnesium, potassium, and sodium)	1·4	Not stated	None noted
Arsenic	0·0035	Ditto	Ditto
Free chlorine	0·7	Ditto	Ditto
Sulphur in solution, or gas	0·7	Ditto	Ditto
Acidity	$\frac{2}{1000}$	Ditto	0·00
Alkalinity	$\frac{1}{1000}$	At Hertford 10·78	0·00
Total foreign matter in sewage ...	Not stated	42·34	41·88
Total foreign matter **removed** ...	Ditto	3·60	25·20

On the 30th August, 1887, a joint inspection of the whole course of the ditch and of the outfall was made by a Surveyor from the War Department, accompanied by the Patentee, who was satisfied that "nothing objectionable had been met with" over the whole line.

The War Office stipulated that the sum charged for patent rights was only to be paid "if the War Department are satisfied of the thorough efficacy of your process after the above extended trial." On the 4th October, 1886, the Commanding Royal Engineer, Brighton, officially informed Mr. Conder "that the War Office authorities have authorised the payment of the purchase money of royalty for patent rights," to 24th December, 1899.

It should be remarked that special causes exist which make the test of the iron process at Chichester exceptionally severe. The trial extended over 15 months. The numbers of the contributors to the sewage varied as much as three to one. The long drought of the summer of 1887 dried up not only the subsoil water in the barrack yard, but also all the springs and surface waters that fed the ditch; so that the small supply of clear water that was running therein on the 30th August consisted of what had been, before it left the barrack yard, very strong sewage. More than all, it should be noted that the time occupied by the flow of the sewage from the point where the disinfectant is admitted to the outfall, where the samples were taken, is rather less than four minutes; in which brief space of time such a measure of purification has been effected as brings the effluent up to the very stringent requirements of the Rivers Pollution Commissioners' 5th Report, and renders the purchase of land for the purpose of improving the effluent wholly unnecessary.

The treatment at Chichester is effected by the solution of the iron disinfectant in porcelain cylinders placed in a 10-gallon iron tank, with a regulating outflow pipe leading into the barrack sewer (see *Fig.* 3, *Plate* II.) just before it leaves the barrack yard, 680 feet above the outfall. The ditch has been completely purified by the action of the effluent, and no accumulation or obstruction has occurred in its course from the precipitate.

The extended trial at Chichester, and the subsequent payment for a license for the remainder of the century by the War Department, show that the Royal Engineer officers are "satisfied as to the thorough efficacy of the process" as applied to sewage in the sewers. The experience obtained at Guildford, Clifton Castle, Windsor Castle, Compton Rectory, and other places, however, tends strongly to confirm the opinion of Mr. Dibden, Dr. Duprè, and other authorities, as to the paramount advantage of treating all drainage in the house, or as near as possible to the sources of pollution.

The FERROMETER, which is the instrument used for applying the process to ordinary house drainage, has somewhat the appearance of a barometer (see *Fig.* 6, *Plate* I.), and consists of a glass dissolving tube *A*, which dips into a porcelain cup *B*. The porcelain cup is divided into two unequal parts by a perforated tin plate *C*, into the larger of which the dissolving tube can work up and down, and from the upper part of the smaller of which the escape pipe *D* leads away to the sewer. Water is admitted to the porcelain cup through the tap *E*. The depth to which the dissolving tube dips into the water is regulated by a brass clamping collar *G*, which will hold the tube in any position. In the new pattern ferrometers an extra tap *F* is supplied at the bottom of the porcelain cup for discharging disinfectant over sinks, etc., as used at Windsor Castle.

The dissolving tube of the ordinary ferrometer contains three pounds of prepared sulphate of iron. By regulating the depth of immersion, and the flow of water, this quantity may either be dissolved in twelve hours, or may last for as much as three weeks. The proper quantity to be dissolved depends on the number of contributors to the sewage to be disinfected.

The conveniences on the premises of the manufacturers, Messrs. Filmer and Mason, of Guildford, are used by between 60 and 80 men. Previous to the use of the IRON SYSTEM, the locality was very offensive, especially in hot weather. Since February, 1887, the locality has been kept perfectly free from smell by the solution of one pound of the commercial sulphate of iron per diem. The public urinal in North Street, the Capital and Counties Bank, and various houses in Guildford and the neighbourhood, are now supplied with ferrometers, and it is noted that where this is the case the cesspits have been cleared out without any unpleasant smell, and that the outflow pipe from the factory into the river Wey is the only one that is free from foul deposit and sewage fungus.

The application of the iron process in the dwelling house, by means of the ferrometer, has many advantages over the application in the sewers. The more immediately the disinfectant is applied to the sources of pollution, the less is the proportionate quantity required. About 30 per cent. less iron is used, per individual, on the premises of Messrs. Filmer and Mason than at Chichester Barracks. In such a case as that of London, where the untreated sewage is collected in mass at two points more than twelve miles from the centre of the area drained, the saving to be effected by treating the sewage, especially in the higher districts, before it is churned up by the long flow, would be considerable. The sewage of the higher zones, if defecated in the houses or at the head of the sewers, might be run as clear water into the Thames without being taken to Barking at all; and the saving thus practicable, added to the further saving to be effected by pumping water instead of sewage at the various lifts on the Metropolitan system, would amount to probably £30,000 out of the £48,000 now expended by the Board on their pumping stations. A further saving of from £10,000 to £15,000 a year would be effected in the cleansing of the sewers; while the cost of treating the sludge would be reduced by more than nine-tenths.

Another advantage gained by the ferrometer in practice was quite unexpected. This is the destruction, not only of permanent, but also of occasional bad smells in the house. In most watercloset arrangements disagreeable smell is observed when the closet is used. This is mainly due to a collection of sewer gas in the fittings, which escapes when the handle is drawn up. When a ferrometer is connected with the closet, no gas is formed; and there occurs nothing to give evidence of the vicinity of the accommodation.

The following incident shows the value of the IRON PROCESS as a means of preventing the poisoning of springs and wells by neglected drainage. A house at Guildford, on change of occupancy, was found to be pervaded by an offensive smell, although it had just passed through the hands of a sanitary surveyor. The medical adviser of the family recommended a ferrometer, which was accordingly fixed, and which removed the smell. On digging outside the house some few weeks after, it was found that the drain pipe was broken and disconnected, and that the whole of the sewage had for a considerable time been soaking into the soil, causing the nuisance described. But since the IRON PROCESS had been at work, the iron solution had accompanied the sewage, and had destroyed its poisonous character within the earth itself. The drain was repaired and the soakage removed without any further trouble. The value of such a method of preventing the pollution of underground water will be at once apparent.

From the foregoing *data* it is claimed that the IRON PROCESS, as now carried on, affords the following remarkable advantages:—

It provides a means of rendering stable the solutions of iron and its salts, in a manner which, four years ago, was declared on high chemical authority to be impracticable; and allows of the automatic supply of an exactly determined quantity of iron where required.

It works with an altogether unexampled rapidity, utilising the darkness of the drains and sewers, and the natural movements of the water supply.

It is distinguished from all processes which are adopted to effect precipitation, in the fact that it splits up, or resolves into harmless elements, the putrescible matters which are the cause of sewage pollution.

As a secondary effect, it produces a fine deposit, chiefly consisting of mineral matter, which has no tendency to associate water, or to form a semi-fluid or sludge. For equal quantities of matter removed from sewage the deposit formed by the iron process is only from one-eighth to one-twentieth part of that formed by any existing method.

The deposit thus produced is inoffensive, perfectly manageable and of appreciable value.

Obnoxious smells and sewer gas are not produced below the points where the iron solution is mixed with the sullage.

No foul matter collects in the drains below such points, and no cleansing by hand is required.

The purchase and preparing of land, the construction of large settling tanks, and the use of steam pumps and other machinery, are rendered unnecessary.

Bacterial life, and the germs of disease, are destroyed in the sewage treated; and foul sewage is, in an extremely short time, converted into a scentless, limpid, and potable effluent.

If the absolute control of sewage impurity which is obtainable by the iron process could be secured, let us say, at the same cost as that incurred by the ratepayers of London, in 1886, for turning the bulk of the Metropolitan sewage in a crude state into the Thames, there would be little hesitation in any impartial mind as to the advantage to be gained by its adoption. But a reference to the table on p. 29 will show that the advantage in point of economy is hardly less than that gained in efficiency.

As to the first item, the facility afforded of treating the sewage either in the house, the cesspit, or the sewers, will render unnecessary a large amount of reconstruction, which would otherwise be required by the introduction of a systematic main drainage.

In the main drains, the cost of ventilating apparatus and ventilation is rendered unnecessary, as well as plant and labour for cleansing the sewers by hand.

Outfall works are reduced to a very trifling cost; the size of the catch-pits that may have to be provided for the deposit (which will be a remunerative outlay) not being more than one-fortieth part of the tank room necessary for subsidence when a precipitating process is employed.

Steam power, mixing machinery, and pumping apparatus may, as a rule, be dispensed with. Where the levels render pumping requisite, the cost will be materially reduced, as it will only be necessary to pump clear water instead of sewage.

The costly and perplexing problem of the acquisition of land and its preparation for the reception or passage of sewage will be easily solved, as the effluent from the iron process does not require any secondary purification by passing through land.

The cost of labour is little more than nominal, as all that is required is to visit the dissolving tanks or other apparatus, and charge the cylinders with the disinfectant once, twice, or three times a day, as the case may be. For the removal of the precipitate, the cost will be covered by the value of the material obtained.

The cost of chemicals will not exceed from 5d. to 6d. per unit of population per annum. The process which has been in operation at Guildford since February, 1887, costs much less than the smaller of these two sums. Chloride of lime costs three times as much, carbolic acid in powder nearly three times as much, and crude manganate of soda four times as much, per ton, as the disinfectant used at Chichester ; and the quantities of either of the three former chemicals required for use are much in excess of those employed in the iron process.

Although the iron process is thoroughly effective in the destruction of *bacteria*, as well as of putrescible matter, it is favourable to the development of the higher forms of life, both vegetable and animal. The precipitate is black while wet, but dries in the air until it resembles fine garden mould. This deposit, whether containing a small quantity of ammonia or not, is of great value as a manure, as the mineral elements of which it mainly consists are exactly those required for plant food, and occur in the precise proportions proper for assimilation. There is no blackening of the vegetation, which grows freely to the very edge of the water. Very fine bright-coloured frogs are now found in the formerly dirty ditch at Chichester, and a considerable deposit of frog-spawn was observed in it on the 30th August last.

It is satisfactory to be able to add that the city authorities of

Chichester, whose preceedings against the War Office for polluting the ditch previously mentioned, by the sewage effluent from the barracks, led to the application of the War Department to the Patentee, have themselves officially applied to him for advice as to the sewage of the Chichester Infirmary; after the City Surveyor had the opportunity of observing the steady improvement of the water-course in question by the effluent from the iron process, and its actual inoffensive condition.

In conclusion, it should be observed that the cost per head of the installation of the IRON PROCESS, including patent right to December, 1899, is less than one-twentieth part of that incurred in the most recent cases of providing for that double process, of precipitation and irrigation, which is at present found to be necessary to produce an admissible effluent by any other system.

Where catch-pits are required—and they are recommended everywhere in consequence of the value of the deposit—if cleared out once a week they need only be of the capacity of 30 cubic feet for every 1,000 individuals contributing to the sewage. Exclusive of this small and remunerative cost, the whole expense of installation and royalty is only £36 5s. per 100 individuals, an outlay that will be recouped to the licensees, within five or six years at furthest, by the saving effected by the operation of the iron process. A table of comparative annual cost will be found in the Appendix.

The nearest approach that has yet been made to the efficacy of the IRON PROCESS has been by the application of either a natural chalybeate or a ferruginous mineral to sewage, as at Buxton, Southampton, and Acton. In none of these cases, however, has a granular and inoffensive deposit been produced, but the sludge has been foul and semi-fluid. The use of natural chalybeate water has only a restricted local interest. At Southampton, the mineral is applied as a powder, containing iron, alumina, and carbon, which is placed in a perforated box, and washed into the outfall sewer by a small stream of water. It thus mixes mechanically with the sewage, which immediately falls into a large tank, where it is allowed to settle. As the sludge subsides, the supernatant water is drawn off from the surface, and is discharged into the tideway. The sludge is forced by a Shone's ejector through nearly a mile of 4-inch pipe to the Chapel Wharf, where it is mixed, by two operations, with the contents of the dust-bins of the town, and made into manure of two kinds, which find a sale at 2s. 6d. and 1s. 6d. per ton respectively. A refuse destructor of six cells is erected at this wharf, which consumes the dust-bin refuse and any of the sludge that is not sold, and thus furnishes ample heat for the steam engines which compress the air for the ejectors, and work the incorporator for mixing the refuse with the sludge. The cost of the destructor was £3,300, that of the ejectors and mains £3,000, and that of the tanks £4,000. The cost of the intercepting sewer is not given.

Eight tons of sludge are produced per day from 500,000 gallons of sewage, contributed by 13,000 persons. The sewage contains by analysis 99·2 grains of solid matter, of which 36·0 are organic, per gallon. The effluent contains 55·6 grains of solids, of which 8·3 are organic and volatile matter, per gallon. The 43·8 grains thus removed from each gallon of the sewage form 256 grains of semi-fluid sludge, or 5·8 times the weight of the solids removed from the sewage.

The population of Southampton is 63,000, of which number only about 13,000 are contributors to the outfall described. There is an outstanding debt of £45,861 for sewage and sewage disposal, and the annual expense under this head, not including interest or depreciation, is £2,185. Of this sum about £1,180 is the cost of the collection and disposal of the house refuse, which forms the fuel used for the steam power, and which, together with the street sweepings, is used for mixing with the sludge.

The annual cost for labour and chemicals is given by Mr. Bennett, the town engineer, at 8½d. per unit of the smaller population. Adding the cost of fuel and material for mixing, and deducting the produce of the sale of manure, the annual cost amounts to 1s. 10d. per unit for working expenses, and to 9½d. for interest and sinking fund, or 2s. 7½d. in all. A description of the works, illustrated by drawings, is given in Volume XCI. of the *Minutes of Proceedings of the Institution of Civil Engineers*. In Volume LXXXVIII. of the same series, p. 279, it is stated by the Borough Engineer of Leicester, Mr. James Gordon, M.I.C.E., "that the Porous Carbon Company, to whom he offered every facility to prove the efficacy of carbon, in Leicester, with a view to its adoption if successful, had utterly failed, under the superintendence of their advising chemist, Dr. Angell, to produce any appreciable effect upon the sewage of this town." This is the Company whose process is above described.

A somewhat similar process, complicated by successive treatments, and by the use of filter beds, is now being introduced by the same chemist at Acton, where £76,000 has been spent on land and works. The population of the sanitary district at the last census was 17,000 and only 500 houses are at present connected with the works. The sewage flows into tanks, where it is treated with a mixture of the sulphates of aluminium, calcium, and magnesium, which coagulates the matter in suspension. It is then mixed with the ferruginous mineral powder, and left to stand for three hours, after which the supernatant fluid is drawn off, and passed through filter beds composed of the same material and of sand. The sludge is further mixed with chemicals, and passed through compressors, which form it into cakes, of which 3,400 pounds are produced daily. The average number of inmates per house throughout England is 5·37, so that 3,000 persons is an over-allowance for the population actually accommodated. On that allowance the sludge-cake produced amounts to 3·2 cwt. per head per annum, or one-third more than the usual average. No analyses are given. The effluent appears free from ammonia, and of a lustrous character, which seems to intimate the presence of metal in solution. The filter beds are at present quite new, but no filter beds have hitherto proved anything but a nuisance after continued use.

The great waste of power that is involved in the compression of air for such purposes as working Shone's ejector is not apparent at Southampton, owing to the unlimited supply of fuel. At Henley, where the only process now in use is the raising the sewage by ejectors to allow it to flow over land, the heating of the air pumps is so great as to require a constant flow of water to keep them in a working condition. The cost of machinery and apparatus in these cases is such as to render the total cost of treatment more than six times as much per head as that of the IRON PROCESS. The sludge difficulty remains unsolved, as in all other processes, and the effluent, as far as analyses have been obtained, cannot compare with that produced at Guildford, Stratford, or Chichester. The table on p. 29, shows that the actual cost at Southampton is 2s. 7½d., and at Henley 5s. 8d. per unit of population per annum.

The proportion of 55·6 grains of solids contained in the Southampton effluent is a little over the average of 52·77 grains obtained in 26 English towns, by various processes, according to the analyses printed by the Rivers Pollution Commission. The general upshot of the treatment is to remove most of the matter in suspension, without much affecting that in solution. But where irrigation is adopted, either alone, or in combination with some precipitating process, this matter in solution is frequently increased by salts washed out from the land. Five English towns have provided about a square yard of irrigation area for each gallon of daily flow, the sewage containing 58·66 grains of solids per gallon. Of this 8·98 grains only was in suspension; 5·45 grains of it being organic matter. The effluent contained 49·21 grains of solids per gallon; and as 1·14 grains of organic nitrogen had been removed from solution, it is evident that mineral matter must to some extent have been taken up from the land, to replace a part of the organic matter abstracted. The German chemists have recently given much attention to this disadvantage attendant on filtration through land. The Teltower See, a lake near Berlin, has been so fouled by the effluent from the Berlin sewage irrigation works as to lead to an action for damages against the city. Professor Müller reports that during nearly six months of the year no vegetation takes place on land, so that it only acts mechanically as a filter bed; and that in frosty weather it is requisite to store up the liquid in tanks. But even when the effluent, in summer, is rendered tolerably free from ammonia, it is charged with nitrogen compounds, lime, potash, and phosphoric acid, so as to render the water of the lake unfit for drinking, bathing, or washing. Dr. König, of Munster, reported to the International Congress of Hygeine, at Vienna, as to the failure of all systems of sewage treatment known in Germany, and even anticipated a return to that rudest of all systems which is in use in some of our great northern towns. The more complete is the information collected from the actual practical experience of either the United Kingdom or the Continent, the more striking is the contrast afforded by the results obtained by the iron process at Chichester, Windsor Castle, Albury Park, Stratford, Guildford, the premises of the Junior United Service Club, and other places; and the more important appears the guarantee that is offered by its adoption, both for the health of the army, and the purification of the houses and streets, the wells and springs, the rivers and watercourses of the British Empire.

APPENDIX.

Water Service of Rome and of London.

The nine aqueducts of Imperial Rome supplied, according to Professor Leslie, 13,000,000 gallons of water per hour to a population of 1,000,000. The maximum hourly flow of the Tiber is 86,000,000 gallons. The water supply was therefore 312 daily gallons per head, and the organic pollution of the Tiber from the sewage of Rome was only at the rate of about 0·53 grains per gallon.

The eight Water Companies of London supply, according to Mr. Alfred Lass, 6,500,000 gallons of water per hour to a population of 5,300,000. The minimum hourly flow of the Thames, after receiving its last affluent, is 21,500,000 gallons. The water supply is at the rate of 30½ gallons daily per head, and the organic pollution of the Thames from the sewage of London is at the rate of 8 grains, and from that of the entire population of the water-shed, if falling into the river, 10½ grains per gallon.

By the works now in process it is proposed to remove from the effluent at Barking and at Crossness 35·5 per cent. of the total solids found in the London sewage. The result, according to the figures of the Metropolitan Board of Works, will be the daily precipitation of 4,830 tons of wet and putrescent sludge. The iron process would remove more than twice the amount of organic matter, producing a dry deposit of less than one-fifteenth of that weight for equal quantities of matter removed.

Disposal of Sewage.

The following tables show the comparative cost and efficiency of the principal methods now in use in England for the treatment of sewage :—

Actual cost of Principal Existing Methods per 1000 Units of Population.

		Capital Cost. £	s.	d.	Annual Cost. £	s.	d.
IRON PROCESS, Installation and Royalty ...		362	10	0	41	13	4
Same in Factory		60	0	0	12	8	4
Southampton ...	Part of Cost. Porous Carbon ..	800	0	0	137	10	0
London	Part of Cost. Lime and Iron...	1500	0	0	120	0	0
Leeds	Part of Town. Lime and Land...	2000	0	0	187	10	0
Windsor... ...	Lime, Iron, and Land	3825	0	0	283	6	8
Henley	Pneumatic Pumping and Land...	4000	0	0	283	6	8
Manchester ...	Pail System				265	16	6
Birmingham ..	Part of Town. Lime and Land...				170	16	6
24 Towns ...	Irrigation (1876)...				93	15	0
Do. ...	do. (1886)...				212	10	0
Wandie Valley...	Lime and Land	7250	0	0			
Hendon	Lime and Land	8200	0	0			

Comparative Efficacy of Principal Methods.

Weight of solids per Million Gallons in	Sewage.	Effluent.	Sludge.
	Cwt.	Cwt.	Cwt.
Birmingham. Lime and Land	147	72	639
London. Lime and Iron	110	70	616
Leeds. Lime and Land	92	69	240
Coventry. Alumina	76	56	250
Southampton. Porous Carbon	126	71	320
24 Towns		66	
Chichester. Iron (when air dried 20 cwt.)...	61	33·3	25
Kent Water Company's Deep Wells ...		35·8	

Sludge per cwt. of Matter removed from Effluent.

	Cwt.
Birmingham	9·0
London	15·5
Leeds	11·0
Coventry	12·3
Southampton	5·8
Chichester (when air dried 0·82 cwt.)	1·4

Directions for the Fixing and Use of the Patent Ferrometer.

The ferrometer in ordinary use will hold three pounds in weight of the prepared disinfectant. This is sufficient to disinfect for one person for three months, or for three persons for one month, or in the same proportion with reference to the number of inmates in a house.

The ferrometer can be fixed by any good plumber in any part of the premises that may be found convenient. In most cases it is recommended that one ferrometer shall be fixed in the highest water-closet in the house, the pipe that conveys the iron-water being led into the syphon or D trap; and that a second shall be fixed to command the back kitchen sink, in order to extinguish any smell from the water used for boiling vegetables or other sources. It is thus applied by the Master of Her Majesty's Household at Windsor Castle.

The pipe attached to the ferrometer which is furnished with a tap, is to be connected with the water supply of the house. This may be done by connecting it either with the cistern, or with the water-pipes, or by fixing a small cistern of four to five gallons capacity for the sole service of the ferrometer.

The pipe from the outflow of the ferrometer, which is not provided with a tap, is to be connected with the house drains. There is no fear of the escape of sewer-gas through this pipe, as the liberation of such gas is arrested the moment the disinfectant is run into the sewage.

The supply of water necessary is small. The tap may be so regulated as to allow of the passage of only a drop per second, or one fluid drachm per minute, which is sufficient in ordinary cases.

The rate of solution of the disinfectant depends in the first place on the depth to which the tube of the ferrometer is immersed in the dissolving cup; it also depends to some extent on the rapidity of flow through the cup. But the quality and temperature of the water have to be considered. Soft water and warm water dissolve more rapidly than hard or very cold water.

If the number of inmates to be served be specified, the ferrometer will be supplied with the tube arranged accordingly. The depth of the tube which contains one pound of disinfectant is marked on the ferrometer; and by observing the time taken to dissolve one pound, it can be readily seen whether the proper rate of solution is maintained.

If the disinfectant dissolve too fast, the flow of water must be checked, and, if necessary, the tube must be raised on its bearings, so as to have less immersion. The contrary if the rate of solution is too slow. It will usually be best to stop the flow of water during the night.

A slice of lemon to be placed every week in the bottom cup.

Ferrometers can be obtained from Messrs. Filmer & Mason, Guildford, at a cost of £3 3s. 0d. each.

Water Consumption of the Ferrometer.

From the "Surrey Advertiser," October 1, 1887.

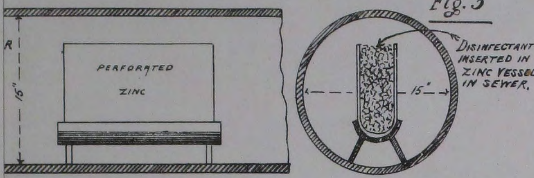
Now that the ferrometer, which is displayed in the warehouses of Messrs. Filmer & Mason, Guildford, is coming more and more into use, the question of the consumption of the water assumes considerable importance. This matter was carefully investigated by the Royal Engineers before the adoption of the instrument at Windsor Castle. When the water supply is regular they found that the ferrometer can be set to run at the rate of a drop a second, which is equal to 4½ pints in 12 hours. In most cases it is unnecessary for the flow to continue during the night. It is obvious that the instrument will rarely be erected for the use of a single individual. The average density of population in the United Kingdom is a little over seven inhabitants per house in the metropolis, and five inhabitants per house in the rest of England. Five persons would require 22½ pints of water in 12 hours. This is a very moderate flow. In the case of the ferrometer at work on Messrs. Filmer & Mason's premises, the flow has been repeatedly gauged. It is at the rate of 51½ gallons in 12 hours, for from 70 to 80 men. But here, for obvious reasons, the quantity needed is more than in more carefully constructed conveniences. As applied in North Street, the quantity of water passing through the ferrometer is less than a tenth of that actually used when water alone is run without any disinfectant. Roundly speaking, then, by the use of the ferrometer in railway stations and other public conveniences, there is an economy of about 500 gallons of water per hundred individuals per day, which is equal at the price charged by the Guilford authorities to £9 per year. The cost of the process does not exceed £2 10s. per year for 100 persons. This refers to cases where water alone is used. In most cases of this nature, however, chloride of lime or carbolic acid are applied, and that in a very rough manner, and with a very unsavoury effect. The cost of these chemicals is more than three times as much per ton as that of the disinfectant used for the iron process; and the quantity, as roughly applied, is more than five times as much as is required for the effective method of solution prescribed by Mr. Conder's patent.

Discharge of Sewage into the Sea.

The latest experience of the discharge of sewage matter into the sea, on the plan adopted by the Metropolitan Board of Works, is as follows, according to the report in the *Times* newspaper of 29th March, 1888, of the meeting of the Board on the previous day.

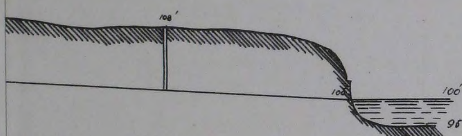
Mr. George Edwards observed, "It was said that when the sludge was discharged from the sludge-ship it would sink to the bottom of the sea. Instead of that, it was found that the whole of the sludge, when discharged from the vessel, left its mark on the sea for miles and miles, and it might be supposed that it would gradually drift to seaside resorts." Mr. G. B. Richardson said, "they would surely find that the sludge would find its way to Margate and other watering-places before two months had passed, and the result would be that an injunction would be obtained to restrain the Board from putting any more sewage sludge into the sea." Mr. E. Laurence said "the effect of casting so much sewage matter in the sea would be to create a pestilence."

Fig. 3



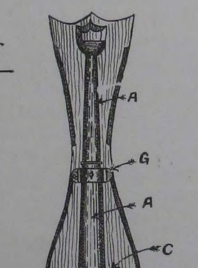
ELEVATION

SECTION



UILDFORD

Fig. 6



FERROMETER

PAPER II.

TYPES OF WORKS FOR COAST DEFENCE.

By Major J. F. Lewis, R.E.

In commencing this account of the Types of Works for Coast Defence, I wish to point out the importance of the subject to English Engineer officers, due to the fact that we have so many Coast Fortresses, more than any other Power in the world. Besides the twelve so-called Military Ports, there are the same number of Coaling Stations, some of which will have more importance in war time than the Military Ports. It is, moreover, proposed to fortify about the same number of Commercial Harbours in the United Kingdom. This is independent of the defences of Australia and India, and of many minor batteries at home and abroad. The probabilities are, therefore, that every Engineer officer in the ordinary course of his service will be engaged in constructing or altering Coast Batteries.

Coast Batteries are places where guns are mounted for the purpose of firing at ships or boats.

In designing a Coast Battery its purpose should be kept clearly in view; the convenient and secure service of the guns being the first consideration; and other things, such as security against assault, arranged to interfere with this as little as possible. In this it differs from a land work. It also differs from a land work in the nature of the attack which it has to resist.

It is liable to have projectiles thrown at it from the most powerful guns made, far exceeding in weight anything which it is possible to use in siege works.

It is also liable to have the fire of a large number of guns concentrated on it at one time. But these guns cannot fire with the regular precision of a siege battery, nor can the attack, however violent for a time, be kept up for very long. Difficulties of ammunition supply, and the great physical and mental strain on the crews of the ships, preventing it.

Thus the worst that a Coast Battery can experience is a violent and concentrated attack, but not one directed with great precision, nor of long duration.

On the other hand, the peculiar difficulty that the Battery has to contend with is that the guns must be capable of being directed at moving objects. Their fire must, therefore, cover a considerable area of water, and the guns must be easily and rapidly trained and elevated.

The result of this combination of requirements is that not much attention need be given to securing a Coast Battery against a succession of accurately aimed shots, but a good deal to protecting vital points against single projectiles of great power; while the chief thing to attain is the easy and rapid service of the guns, including loading and pointing.

English Coast Batteries may be mainly divided into two groups. Those built for the old short ML. guns, and those for the new long BL. guns. There are also new batteries for old guns, and works to contain rifled howitzers, and for machine guns.

There are large numbers of the old batteries in existence; indeed, they form at present the only defence of our Military Ports; it is therefore desirable to describe them. It is also necessary to do so in order that you may appreciate the differences which have been made in the new works, and also that you may understand the proposals made to strengthen these old ones in order to utilize them in the face of modern weapons.

Old Batteries for Heavy M.L. Guns.—The old works may be divided into five classes :—

1. Barbette batteries.
2. Batteries with open battery shields.
3. Masonry casemates with iron shields
4. Continuous iron fronts.
5. Moncrieff pits.

(1). In the first class the guns are usually placed behind a parapet from 20 to 30 feet thick, with a regularly formed interior and exterior slope, and a ditch; the whole neatly finished, and easily recognisable from the exterior as a Battery. The guns are from 40 to 100 feet apart, and are separated from one another by traverses, generally containing ammunition chambers or serving rooms. These traverses are almost invariably raised to a height of three, five, or even eight feet above the crest of the parapet over which the gun fires, and being made with steep sides give a very marked indented outline against the sky; and in sunlight a succession of dark shadows, marking clearly the position of the guns.

In the interiors of the Batteries the arrangements differ according to the nature of the guns. Originally all barbette guns of every calibre were mounted to fire over a parapet 4 feet 3 inches high above the top of the racer, and all the operations of loading, traversing, and elevating were performed by men standing on this level, and, therefore, only partly protected. Efforts were made to improve this, but as, until quite recently, no alteration was made in the mounting of the guns, it was impossible to give more security to the men traversing and elevating. The supply of ammunition and part of the operation of loading were rendered safer in cases where a circular racer was used, by cutting a sunken way round the front of the emplacements of heavy guns, between the parapet and the racer-blocks. It was necessary to mount out of this sunken way in order to insert the charge in the bore, and this difficulty has never been satisfactorily got over, but on the whole the cover was much improved. There are still in existence batteries which have not been provided with a sunken way.

The ammunition stores are either on the level of the gun emplacements or sunk below them. In the latter case the projectiles and cartridges are hauled up by means of tackle through shafts in the walls called lifts. These deliver either in the parapets near the guns or, more usually, in serving rooms under the traverses. From thence the ammunition is either wheeled or carried to the guns. The construction of these serving rooms resulted in the gun emplacements being very deep, and bounded by vertical walls which are well calculated to burst the enemy's shells.

Several limitations in the dimensions, rendered necessary by the short distances between the guns, made it impossible to give these serving rooms protection which would be sufficient against modern projectiles.

The horizontal arcs of fire given to barbette guns varies considerably, and is affected by the nature of racer used. Many of the earlier batteries were built for A pivot racers—that is to say racers whose pivot is in front of the platform. Guns on these racers fire through embrasures, and are limited to 60 or 70 degrees training, or to 90 degrees as an extreme case, but this does not make a well proportioned emplacement. The guns cannot have sunken loading ways constructed for them, as there is not enough room between the parapet and the front racer. *Ex.* : Southsea Castle, Newhaven, Dover Castle, South Hook (Pembroke), Shotley (Harwich).

All, or nearly all, the 9-inch ML. guns mounted in India were on A pivot racers, with very aggravated vertical sided traverses of masonry. They had about 90 degrees training.

These Indian batteries were built when the new large machine guns were just coming in. English designs of the same date have the guns at 100 feet intervals, with solid earth traverses, sunken loading ways, and with under-cover loading applied to the smaller guns. This illustrates the necessity of keeping pace with modern improvements.

The great disadvantage of an A pivot mounting is that the angle of traverse is absolutely limited by the sides of the emplacement. Consequently a gun is liable to be attacked by fire to which it cannot reply.

Where large arcs of fire are required, the guns are mounted on C or D racers. With C racers the pivot is central, and the racer a complete circle. With D, the pivot is in rear of the centre, and there are two racers. The arrangement of the gear on the platform used to render the D pivot essential for arcs of traversing of over about 150 degrees.

Examples of these mountings will be found in all the Imperial coast fortresses, the so-called Military Ports.

(2). Batteries with open battery shields resemble barbette batteries with A pivot emplacements in every respect, except that the embrasures are closed with iron shields, and the guns fire through arcs of 60 degrees only. There is no overhead cover, although arrangements are made for adding it when required. The plates of the shield are supported by an iron frame, which is bolted to the floor, or in other ways strengthened against displacement by the blows of projectiles. It is probable that the precautions thus taken are insufficient against modern guns, and, moreover, none of the open battery shields are of sufficient thickness to resist heavy modern projectiles. *Ex.* : Thames, Malta, Gibraltar, Halifax, Bermuda.

Some open battery shields have had roofs of iron and concrete added. They then merge into the following class.

(3). Masonry casemates with iron shields. There are two large double-tier batteries of these (namely, Garrison Point Fort, Sheerness, and Picklecombe Fort, Plymouth), and a large number of single tier batteries, varying somewhat in detail, at Portsmouth, Plymouth, Thames, Medway, Harwich, Cork, Milford, Portland, Malta, Gibraltar, Bermuda, and Halifax.

In these batteries the guns are mounted on A pivot racers, and fire through ports in iron shields, covering arcs of 60 degrees. These shields are enclosed with masonry piers and arches, and the gun-chambers are arched over. The magazines are, as a rule, underneath the guns, the ammunition being sent up by lifts.

In most of these batteries the interval between the guns is 24 feet. As the shields are 12 feet wide, this only leaves the same amount for the masonry pier. The thickness of the pier is from 12 to 14 feet in the centre, but the corners are taken off to allow the gun to traverse. Consequently the whole pier is so small that it might be carried away by a blow from a modern heavy projectile. The shield is also liable to displacement, as it is partly dependent on the pier for its stability. The overhanging arch stones above the shield are also objectionable, being easily injured, and not of a form which would deflect a shot. The wall of the ammunition stores below the guns is usually of the same thickness as the piers, *i.e.*, 12 feet, and is, therefore, penetrable by heavy projectiles. Another weakness is caused by the short distance—four feet, about—to which the masonry of the gun floor extends in front of the shield. A projectile striking a little way below the shield would be almost certain to disturb the level of the front racer at least, and thus put the gun out of action.

After mentioning all these weak points, it is only fair to say that before this form of battery was adopted in 1865, an experimental casemate stood a severe hammering at Shoeburyness from the heaviest guns of the day.

(4). Continuous iron fronts. Complete walls of iron are used in certain important positions instead of masonry casemates or shields. The examples are the Spithead Forts, the Breakwater Forts at Plymouth and Portland, and Fort Cunningham, Bermuda. These works are provided with iron roofs covered with concrete, and the magazines are below the gun floor. The armour is penetrable by projectiles from modern heavy guns, but it is arranged to take additional plates if necessary. I do not imagine the iron wall could be displaced by blows. In all the cases, except at Breakwater Fort, Portland, there is inadequate protection for the magazines, and also for the gun-floor below the armour as with the masonry casemates.

A form of emplacement, of which there are eight examples in all at Gibraltar, Malta, and Portsmouth, is the Curved-fronted Casemate containing one gun on a turntable, which is thus enabled to fire through two ports and to command an arc of 120 degrees. It is like a short length of continuous iron front.

The British nation also possesses one turret for two 80-ton ML. guns on Dover pier.

(5). The fifth class of battery for heavy ML. guns is that for the Moncrieff counterweight carriage. This has not been used for guns heavier than seven tons, except in the case of two 12-ton guns at Newhaven. Seven-ton guns are mounted at the Severn and at Cork, and there are batteries for them at Milford, but built in such an unsuitable and weak manner that they have been disarmed. The batteries are like barbettes with high parapets, and without traverses above the level of the crest. From an engineer's point of view the best of them are very good. The objections lie in the mounting, which is cumbersome and constantly getting out of order; the use of it has, therefore, never become general.

Medium Gun Batteries.—Besides heavy guns, a large number of smaller ones are mounted on sea fronts. These, when muzzle loaders, are usually classed together as medium guns—not a very accurate term, but a convenient one, which may be taken to include all permanently mounted guns not firing armour-piercing projectiles (strictly all guns under five tons weight and above 40-pounders). These are useful for firing at the unarmoured portions of ships, and at smaller craft. They are all mounted *en barbette* or behind embrasures, or in masonry casemates. The latter may nearly all be considered obsolete.

The barbette and embrasure batteries are similar to those for heavy guns, except that the dimensions are smaller, and that sunken loading ways are not used.

The New Era in Artillery.—I have now described the various forms of Coast Battery in use during the era of short ML. armour-piercing guns. The new era may be considered to have begun about nine years ago, when almost simultaneously improved machine guns, quick-firing guns, and long BL. guns, firing projectiles with a high velocity, were produced. Its influence was immediately felt, and was manifested in numerous projects for improving the protection given to the old guns, both by altering the mountings and strengthening the works. Most of the attempts at improving the mountings were, I regret to say, failures, but two or three survive. I will describe them further on. The designs for strengthening the works have all been superseded by later projects.

Very little new work in fortification was done during the first four or five years of this period. Several batteries for 7-inch and 64-pounder ML. guns were thrown up in the Colonies in 1878-9, in anticipation of a war with Russia. These were somewhat more solidly made than had been usual, the guns were more widely spaced (100 feet from pivot to pivot), and a somewhat improved mounting was introduced for some of the 64-pounders, enabling them to fire over a parapet five feet six inches high, but many of the guns were mounted on naval slides, firing over a parapet only two feet six inches above the racer—these being the only carriages available in a hurry.

The pressure that existed in turning out new guns for the Navy rendered it impossible to procure any for land works for some time. It was, however, decided that the sea faces of the two large Spithead forts should be armed with 12-inch 46-ton BL. guns, instead of the 12·5-inch ML. guns, which had not yet been supplied.

The necessity of facing the problem and deciding on the nature of guns, mountings, and batteries to be used for coast defence became pressing when the fortification of the Coaling Stations abroad was decided on in 1883. This measure involved the creation of several new fortresses and the revision of others, the works to be altered being in all cases of early types. The armaments were mostly to be a combination of BL. and ML. guns, but were in some cases to be all ML. guns. There was no land mounting in the service for the new BL. guns, except one suited for casemates. A cupola—which may be described as a light turret with sloping sides—was under construction for a 26-ton BL. gun, but it was not generally viewed with favour. The mountings for the old heavy guns were looked on with dislike, but the efforts to improve them had not been successful. The ML. guns were about on a par with the mountings. The heavier QF. guns were not yet out of the experimental stage. The new type of fighting ship which might engage those works had not yet taken a definite form. Under these circumstances it may be imagined that there was a considerable variety in the designs. The earliest did not differ materially from the old ones. But it is of no use going through the history of the various changes; eventually some guiding ideas were generally accepted, which underlie the various shapes that the new batteries have assumed.

Influences forming the New Designs.—The fact which has had most influence on the designs is the necessity for economy both in money and in men. This has been since intensified by the greatly increased cost of the guns, their mountings, and their ammunition, over what it was at first expected to be. Originally there was no idea that it would much exceed that of the old patterns; now, however, a 6-inch BL. gun of four tons, on an HP. mounting, with 200 rounds of ammunition, costs £3,500; the same as a 10-inch ML. gun of 18 tons, on a barbette mounting with its ammunition. A 9·2-inch BL. gun of 22 tons, similarly provided, costs about £10,000, and a 10-inch BL. of 32 tons, £15,000.

New Mountings.—This economy has necessitated getting as much work out of each individual gun as was possible, and they are, therefore, intended to have large arcs of fire. Their mountings must be, therefore, necessarily some modification of the barbette or of the turret; shields are out of the question, as limiting the arcs too much. Moreover, the sudden reduction in the value of our armoured defences, due to the new guns, had made the authorities averse to sinking more money in similar structures, which would be more costly to begin with, and might be superseded with equal rapidity. At first the only mounting proposed for the larger guns was the cupola, but Sir William Armstrong's firm were making barbette mountings for the Australian Colonies and for foreign Powers, and also struck out in a new direction with a hydro-pneumatic disappearing mounting for the 6-inch BL. gun. On this mounting, which is an off-shoot of Moncrieff's counterweight system, the gun is loaded under cover of the parapet, and is raised into the firing position by the elastic force of compressed air. This compressed air also absorbs the shock of recoil. This system was taken up by the Australian Colonies, who have led the way in the matter of coast defences, and they advanced to ordering an HP. mounting for the 8-inch BL. gun of 14 tons. This emboldened the Elswick firm to propose mounting the 9·2 inch of 22 tons and the 10-inch of 32 tons in the same way. The firm of Easton & Anderson, representing Colonel Moncrieff, who have had considerable experience with disappearing mountings, offered to do the same.

The results of all this are that, for the 6-inch BL. gun, the service mounting is the hydro-pneumatic one of Sir W. Armstrong & Co.

For the 9·2-inch BL. gun a barbette mounting by the Elswick firm (Sir William Armstrong & Co.), has been tried at Tynemouth, and is now being made for the service. Another barbette mounting for the same gun, produced by the Royal Carriage Department, has just been tried at the same place. I do not think it will be repeated. Similar barbettes will also be tried with the 10-inch BL.

Hydro-Pneumatic mountings for the 9·2-inch and 10-inch BL. are also being prepared for trial both by Sir W. Armstrong & Co. and by Easton & Anderson. The 9·2-inch mounting by the latter firm has been partially tried at Shoeburyness. As far as the disappearing principle is concerned, it is a perfect success; the motion of the gun in recoil was very easy, but a number of minor defects have made themselves apparent, which are now being remedied. The remaining mountings have not yet been tested. The trials of the Armstrong HP. for the 9·2-inch BL. are nearly concluded, and are in every way satisfactory; the mounting is compact, handy, and easily worked.

The cupola before alluded to as the first method proposed for mounting the new guns was tried last year at Eastbourne, but it had been practically condemned before trial. It was far more costly than the barbette, or even than the H.P. mounting, while it did not give an equivalent increase of protection; as a machine it worked successfully. It might form the basis of a design for a small turret, if it were required to place a gun on a very restricted site at a low level.

Another fact which influenced the designs was the greatly increased power of the new guns, which has led to a considerable increase in the protection given to vital parts, and to a change in the manner of applying this protection.

Effect of Projectiles—The new high velocity projectile, though acting with terrific effect against steep slopes or vertical faces, into which it will penetrate, is easily turned aside and deflected by surfaces making only a small angle with its path.

The effect against a vertical face was illustrated at Shoeburyness in 1883-4, when the 80-ton ML. and the 12-inch BL. guns were fired at masonry and concrete.

The path of the 80-ton gun shot through the concrete was 34 feet, but as it did not move in a straight line it stopped at a distance of only 25 feet from the face of the wall.

Against the masonry with granite facing the effect was chiefly noticeable for the way in which the granite blocks were displaced and thrown aside all round the point of impact. It was evident that although it is good to have a hard surface to meet a projectile, yet in the form of granite blocks it did more harm than good. The piers used in the old shielded forts, which are 12 or 14 feet thick, would not be merely penetrated, but shattered and completely destroyed by the blow from one heavy projectile of 10 inches calibre and upwards, and possibly even by smaller ones.

Alexandria.—The proper way to resist these heavy blows was distinctly pointed out at the bombardment of the forts of Alexandria, when the shell from the 80-ton ML. gun failed to penetrate a sand parapet 25 feet thick, but was deflected up and out of it. This result was confirmed by experiment, and the application of the fact resulted eventually in a form of coast battery with a very flat exterior slope, the same, or nearly so, as the superior slope. This section was afterwards used for land works, and gave rise to the redoubt constructed at Twydale.

The results obtained at the bombardment of the forts at Alexandria have had great effect on the designs for works. The batteries at Alexandria were low, thin, and badly constructed, yet they suffered little from an attack by eight ironclads, lasting for 10 hours. This was due to a variety of causes. One was the manner in which the shots were deflected by the sand parapets as already mentioned. Another, and a very important one, was the difficulty of seeing distinct objects on which to lay. The general similarity of colour of the coast, the forts, and the buildings helped in this, and the works themselves were, as a rule, not very commanding. It was found very difficult to distinguish individual guns so as to be able to concentrate fire on them, and shots striking anywhere but near the guns produced very little effect. At the end of the engagement ships stood in to within 800 yards in order to dismount guns, thus illustrating the difficulty of seeing them further off. This difficulty of seeing the guns was really the chief protection that the Egyptians had, for the parapets were in all cases weak, and sometimes not high enough to cover the men behind them.

Concealment.—It was plain from this that if gun emplacements were designed to give a reasonable amount of protection, and at the same time the form and position of the batteries were studied with a view to conceal them as much as possible, that they would be practically very difficult to silence. It will be evident that concealment is aided by the conclusions already arrived at, namely, that the guns should be *en barbette*, or disappearing, and that the slopes of the earthwork should be as gentle as possible. But the subject practically is a very difficult one. The colour and surface of a battery should harmonize with the surrounding country, and there should be no well-defined sky-line. These are things that cannot be settled in the drawing office. There, all that can be done is to avoid obvious mistakes, to have no sharp angles which cannot be rounded, or deep shadows that cannot be reduced. A sharp projection a few inches high will show literally for miles against the sky, and a steep slope when the sun is low casts a dark shadow that no artifice will disguise. Nothing is so clearly visible as the salient of a bastion; therefore, all intersections of slopes should be well rounded to a long radius, and all projections such as traverses should have sides at a flat slope; but the final touches must be given on the spot; it is a kind of scene-painting on a large scale. When a battery approaches completion, the engineer in charge should take a boat and slowly cruise round it to study its points, and this at different times of the day, as the shadows alter with the sun. A little cutting here, or filling there, a rounding of slopes, or planting a few bushes may make all the difference. Every battery must be treated individually.

A few examples will make this clear. Thus some batteries were built in 1879 to defend a port in South Africa. They were pretty good in form, but had their slopes covered with grass, while all around them was arid sand and rock; consequently when a ship approach the harbour, the passengers would delightedly call out, "Oh, there are the batteries." On the other hand there are some old batteries at Gibraltar which have in the course of time become so perfectly assimilated to the surrounding ground, that it is impossible to distinguish them, even when their position is accurately known from other land marks.

In the Isle of Wight there is one battery which, on certain bearings, when it is projected against the hill behind, is quite invisible, and can only be localized by the black wooden fencing round it. Black wooden fencing I have several times noticed as being very visible; wire would be better. An adjoining battery, similar in form, always shows up with a hard and angular sky line.

The 100-ton guns at Malta have been rendered very inconspicuous by being painted a light grey, which harmonizes with the stone fences about them.

A battery at Aden is carved out of the back of a natural sand hill, which is undisturbed in front. One would think that nothing could be better, but unfortunately there is a hill of black rock about 100 yards in rear, against which the crest of the battery is sharply defined.

One or two examples of what to avoid may be taken from Aden. An old expense magazine, standing vertically about five feet above the parapet, has been covered with white plaster, worked to a polished surface; it shines like a star; I have seen it glittering five miles off. A quantity of walling among the rocks, which are dark, is built of the same dark stone, but was pointed with white mortar. Every bit of revetment was thus instantly proclaimed as such.

It is proposed to disguise the form of the new works there by an ingenious expedient of Lieut. Dallas, R.E.; it is to cover the surfaces with patches of powdered rock of various colours. All colours can be found there, from almost white, through the reds and the yellows, to almost black; and there is no vegetation to hide it.

Speaking generally, the exterior slopes of a battery should be left rough and untrimmed. They should not be turfed, but sown with the local grass, weeds, and bushes.

The sky-line can be broken by purpose-made irregularities, and if it has not a background one can be given it by planting bushes somewhere in rear of the crest. Trees will seldom be suitable; they grow slowly, they will be too tall eventually, and they can burst shells striking them, and can give off splinters.

You will see from this that the finish to a battery can only be given by the local engineer, who must not consider his work complete if he has merely copied a War Office plan.

Another method of assisting in the concealment of batteries is scattering the guns. This was at one time almost laid down as a law, though I have never been able to discover at what distance apart guns began to be "scattered." As a matter of fact, wide scattering is in most cases undesirable and impracticable. Guns should be gathered into batteries not too large to be controlled by a single officer, and containing guns of the various calibres suitable to the work they have to do. Grouping guns into batteries simplifies construction, command, guarding, and supplying. It does not much affect the concealment, for a single emplacement, say 20 feet across at the crest and with 40-feet parapets on either side, is as difficult to hide as a battery. I mention the parapet because mounting the gun so as to fire over the natural surface of the ground is an ideal case which should always be sought for, but hardly ever expected to be realized.

Sometimes the formation of the ground requires the guns to be isolated, but this is for the sake of good lines of fire and not for concealment.

One good result has come from the "scattering" idea. Guns are now placed at long intervals, 150 to 200 feet from pivot to pivot being considered the normal amount. This renders it essential for the enemy to fire at individual guns if he is to do any harm. It is sometimes difficult to find sites for such large works as are now used, but the long intervals are very convenient in designing the interiors of the batteries; it renders easier the problems of constructing efficient traverses and secure magazines and casemates; of providing a good ammunition service, and sufficient parapet for rifle and machine gun fire.

Nature of Guns to be used.—The final important feature in the design of a battery is the nature of the guns to be mounted. This depends on the construction of the ships to be fired at, and it may here be remarked that an acquaintance with the progress of ship-building is essential to anyone who wishes to be a proficient in coast fortification. It is a very interesting subject.

War ships may, for our purpose, be roughly classified as follows:—

(1). Modern ships carrying only a small proportion of their guns behind armour.

(2). Old ships carrying a large proportion of their guns behind armour.

(3). Unarmoured vessels.

The first and last classes can have nearly all their guns put out of action by small projectiles; indeed, the new long guns, even when in turrets, show a considerable length outside which can easily be injured, so that no guns in modern ships are quite safe. In the second class the old ships do not, as a rule, carry their heaviest armour in front of their guns, and a large percentage of them are not very strongly protected. It follows from this that a gun of the power of the 6-inch BL., firing a 100-lb. shell, is capable of dealing with nearly all the guns that can be opposed to it, and this gun, therefore, should form the bulk of the armament.

The muzzle energy of the 6-inch BL. gun of five tons is 2,556 ft.-tons, and it is capable of penetrating 12·1 inches of iron at the muzzle, the penetration falling to 8·7 inches at 2,000 yards.

It should be remembered that it is not necessary to sink a ship engaging a battery in order to get rid of her. It is sufficient to silence her guns, when she can do nothing more against it.

There remain a few heavily armoured guns to deal with. For this purpose some powerful guns must be mounted on land, their weight depending on the class of vessel that may be expected to attack, and therefore indirectly on the importance of the fortress. For our coaling stations and commercial harbours the 9·2 inch of 22 tons and the 10-inch of 32 tons are being used, and appear sufficient. For first-class fortresses like Portsmouth and Plymouth heavier guns can legitimately be mounted.

As a large number of guns in modern ships have no armoured protection at all, or plates only two or three inches thick, less powerful guns than the 6-inch BL. can be usefully employed. The old 7-inch ML. is such a weapon; it can be securely mounted, and firing a large shell would be effective at ranges within its capacity. The new 36-pounder QF. gun will be a very good one to include in modern armaments.

Six and 3-pounder QF. guns can be used with effect against most ships, and their use will serve to neutralize the similar guns carried by the vessels. These only come into play at comparatively short ranges under 2,000 yards.

A class of weapon that is coming into use as a supplement to the gun, but not as superseding it, is the rifled howitzer. This is good against all classes of ships.

It should be mentioned that a secondary, but very important, use for the larger guns is for firing at vessels attempting to bombard at long ranges. The 6-inch BL. falls off in accuracy at about 5,000 yards, and more hits could be made in a given time with the larger and more accurate guns than with the 6-inch BL., even allowing for their slower rate of fire. Their projectiles would also retain sufficient energy to penetrate light armour. For this reason it is desirable that works intended to protect an important place near them from bombardment should include a proportion of guns of at least the 9·2-inch calibre.

New Batteries.—Having now given an account of the older forms of works, and of some of the reasons which led to changing them, some of the new works may be described. The *Plates* which accompany this paper represent batteries designed for certain actual sites, and which were intended for construction. These drawings illustrated Colonel Schaw's Lecture in Coast Defence, at the United Service Institute, and copies of them will be found in the Journal. They are not "type" plans drawn for imaginary sites and imaginary conditions, which probably never did and never will exist, and which by their appearance of symmetry and completeness look as if they ought to be imitated. An actual battery does not delude in that way. It is designed for Singapore or Tynemouth, or whatever it may be, and it is plain that in another place where the conditions were different, the battery would be different too. These drawings are not *types* but *illustrations* of modern works for coast defence.

The simplest and strongest was designed for Frenchman's Point, near Tynemouth (see *Plate* I.). Having a cliff in front, partly quarried, partly natural, no front ditch or other defence is required. The parapet is of the sloping type and dies out on the ground. The armament is two 9·2-inch BL., and two 6-inch BL. all on H.P. mountings. The guns are placed 200 feet apart, and are 88 feet above the sea. From its position in a hollow in the general line of the coast the battery cannot be enfiladed from the sea or taken in reverse; consequently the guns are all placed in emplacements open to the rear. Any shot missing them will pass by and do no harm.

The battery has but small relief above the ground, and the changes of height are slight and the slopes flat, so that it may be expected to harmonize well with the surrounding flat country.

It is proposed to plant shrubs along the gorge parapet so as to break up the outline.

The ammunition service is from a central magazine for shell and cartridges, to recesses near the guns, from which the charges are taken for use. Casemate accommodation is provided for the garrison, perhaps rather in excess of the requirements, for a naval attack cannot last for long, and there is no need for the men to live under cover. The interior of the battery is sunk so that the communications will be very safe. The gorge is defended by a parapet of the Twydale type.

Another battery was designed for Tombeau Point, Mauritius (see *Plate* II). The guns are old ones, two 10-inch ML. and two 64-pounder ML. The ground it stands on is only nine feet above the sea level, but the use of barbette mountings at such a small height is justified by the fact that a reef off the coast prevents ships coming within machine gun range. The slope of the parapet is prolonged below the ground level, as in the case of Twydale redoubt, the ditch containing an iron fence, and being protected by fire from the parapet. The guns are 200 feet apart. The ammunition stores are in the centre as before, and the immediate service to the guns is by means of recesses. In some cases the centre guns are served directly from the stores by means of lifts, or of ramps which can be used if not steeper than 1 in 7. The defence of the gorge is concentrated at one angle in order to economize men.

Another battery was designed for an irregular site at Stonecutter Island, Hong Kong (see *Plate* III.). The guns are one 10-inch BL. barbette, and two 6-pr. AF. guns. In this case the parapet is worked out of the natural hill, and the near defence is provided for by musketry emplacements, arranged to suit the irregularities of the ground. The guns are about 100 feet apart, there not being room for wider spacing. The ammunition supply is entirely underground, lifts being provided at the angles of the 10-inch emplacement.

In the case of a battery on a low site, which will probably be exposed to reverse fire, the emplacements will be complete circles. Each gun here has its own ammunition storage and service carried on through bomb-proof galleries, variously arranged to suit the conditions of each emplacement.

The drawings fairly exemplify the way in which modern requirements have been met. The batteries would be difficult to injure by modern guns, and could be made hard to distinguish, while as large arcs as possible are given to the guns mounted in them.

Where they are all rather behind-hand, according to our present idea, is in the relative numbers of heavy and light guns. The heavy guns are in excess while the light ones are not numerous enough. I should prefer to change one 9·2-inch for a 6-inch at Frenchmen's Point ; and in some situations an even better change would be to have two 36-pounder QF. guns instead, thus making the armament one 9·2-inch BL., two 6-inch BL., and two 36-pounder QF.

At Tombeau Point the 64-pounder ML. ought to be turned into a 36-pounder QF., or something excelling the 64-pounder in range and rapidity. It will be noticed that at Tombeau and at Frenchmen's Point the batteries are symmetrical, with the heavy guns in the centre and the light ones on the flanks. This arrangement is by no means universal, as it is unlikely that a battery would be equally exposed to attack on both flanks. The rule to follow is to put the heavy gun in the best place—there will seldom be more than one in a battery—and then to arrange the rest so as to command the water thoroughly in combination with other works. In a battery on the flank of a line of works this would usually lead to the lighter guns being placed on the outer flank of the heavy one.

Sometimes the heavy guns will be on the flanks and the lighter ones in the middle, for example, Fort Morbut, at Aden, and Victoria Battery, Jamaica. Each case must be judged on its merits; only if you see in the design for a battery that one gun is not doing so much work as the rest, then consider if it ought not to be moved.

Offence is the best *defence*, and the harder you can hit your enemy the sooner he will be beaten. Try and get every gun to come into action wherever the enemy may be, and don't let any detachment have to stand hungering to get their gun round a few degrees more so as to have a shot at him, and not be able to do it. You must count, too, on having some guns put out of action for a time, and their loss must leave no blank spaces. A little thought put into a design in this way may change the result of an action.

Alterations to Old Batteries.—The old batteries are too numerous, and occupy situations of too much importance to be neglected or replaced by totally new works, but they require alterations in almost all cases to fit them for their present duties. I will take the various classes in the same order in which I described them, and point out what changes are made or are in contemplation.

(1). Old barbette batteries are usually too thin in all directions, too visible, and with indifferent appliances for working the guns. The parapets can be thickened either by filling up the ditch, or by moving the guns further back. An example of the first method is Lower North Battery, Simon's Bay, which was the first design on which the exterior slope was very much flattened. This gave the idea of Tombeau Point Battery, and initiated the new style. Musketry protection is given to the exterior of this battery by carrying the exterior slope up to the traverses, the tops of which are formed with a parapet and banquette. The guns in this battery were 100 feet apart, which was sufficient, so the old cartridge and shell stores were retained, additional concrete protection being carried round them.

An example of the second method may be taken from Southsea Castle, Portsmouth, where a long battery of nine 9-inch 12-ton ML. guns has been converted into one for two 11-inch 25-ton ML. and three 6-pounder QF. guns. Here the guns were very close together, 40 feet from pivot to pivot, and the ammunition stores in the traverses between them have never been really safe. The new guns will be 190 feet apart, and will have parapets at least 35 feet thick. The ammunition stores will be at a lower level in rear of the central traverse. The top of this can be formed for the use of riflemen.

The choice between these two methods is usually not free, but is dictated by the formation of the site. Filling up the ditch is often impracticable. Moving the guns back usually goes with a reduction in their number in order to increase the intervals and thicken the traverses. At the same time it is advisable to alter the mounting in those cases in which the guns are on A or front pivot racers, and to give them larger arcs of fire by using C or central pivot racers.

There is another good reason for using C pivot platforms whenever possible with heavy ML. guns, which is that various improvements have been made in it, which cannot be applied either to A or front pivoted, or to D or rear pivoted, platforms. By placing the racer on the top of a circular drum, and by altering the traversing gear, the latter can be worked from a level seven feet below the crest, instead of four feet three inches. A convenient crane for raising the projectiles is supplied instead of the old muzzle derrick fixed on to the gun, and a stage fixed to the platform is used to load from instead of a moveable one running on rails. The result of these alterations is that the only numbers exposed are those entering the charge and the rammer, those at the elevating gear who are partly protected by the gun, and the No. 1 who lays, who also gets a good deal of protection that way. This is not perfect, but it is better than it was, and there are hopes of doing more. It will be understood that the alteration to the traversing gear cannot be applied to a D pivot platform, but as the sole use for the D pivot was to get a large arc of fire, its *raîson d'être* is now gone, and now it should never be used. With an A pivot the sunken loading way cannot be carried round to the front, and so the loading numbers must be exposed.

The smaller guns can be better treated than the large ones, as their projectiles are easier to handle, and in getting in the projectile lies the great difficulty in loading and working a gun. The 64-pounders and 80-pounders on wooden traversing platforms are many of them now "blocked up;" that is, the platform is heightened so that the gun fires over a parapet six feet high instead four feet three inches. The gun is loaded by being depressed while run back, so that its muzzle comes below the parapet. Its charge and projectile are then introduced while in that position, and rammed home with a jointed rammer. Thus the only man who need show above the parapet is No. 1 while laying the gun. The 7-inch gun of 6½ tons has an iron carriage and platform built for it, which enables it to be worked in a similar manner to the 64-pounder. These guns could keep in action in the face of machine gun fire. There are a good many of them in various places. They can be mounted on either C or A pivot racers, but it is best to use C, as there is no particular advantage in using A to compensate for the limitation in the arc of fire.

In the heavy ML. guns themselves a great improvement has proved practicable. By re-tubing and re-rifling the gun with the modern polygrooves, and by using a better proportioned projectile, the old 9-inch ML. of 12 tons, which used to shoot indifferently up to about 4,500 yards, has been made to shoot well up to 10,000 yards. To attain this latter range a new carriage and platform will have to be designed to admit of 35 degrees elevation. The existing mountings can be altered and employed when such long ranges are not required. This improvement has rendered it possible to utilize the large numbers of ML. guns that are available, and to arm batteries with them so as to be capable of contending with ships provided with modern guns. At the longer ranges, from the height of the trajectory, these guns practically act as howitzers, which is a very effective kind of fire, though difficult to direct.

(2). *Open Battery Shields.*—Here the battery generally might be strengthened in the same way as a barbette, either by filling up the ditch or by moving back the guns, though I do not recollect any actual case in which the former treatment can be followed. The shields themselves can be perforated by shot of no very great weight, or displaced bodily by a blow, or turned, so to speak, by a projectile which may penetrate the merlon where it is weakest, near the junction with the shield. This weakness it has been proposed to remedy by reducing the number of guns and by combining three shields into one. The guns are placed further back; each shield is supported on either side by a shield frame and one plate. The remaining plates, which are two or more according to circumstances, are used to thicken the shield; the plate upon plate construction being specially adapted to this operation.

No improvement is possible with the gun, for it is useless adding to its power at long ranges, since the possible elevation is limited by the port in the shield; the mounting also remains unchanged.

(3). *Masonry Casemates with Iron Shields.*—These are pretty evenly weak all over, and require considerable alterations to make them efficient. A proposal has been made by Major English, the Inspector of Iron Structures, which appears to meet the case, and which it is very desirable should be tried. The cost, however, and the fact that part of the construction is of a somewhat experimental nature, has been against it. The idea is to fill up the ditch (an operation, by the way, which usually comes first in any scheme of re-construction at the present time), to increase the number of plates on the shields, and to protect the masonry below, above, and at each side of the shield by large masses of cast iron, weighing nearly 100 tons apiece, curved on the faces in the manner best suited to deflect shot. The idea of the cast iron is taken from Grüson of Magdeburg, who has made many cast iron turrets and casemates for Continental Powers, but the metal used in these portions, where it is well backed up, is said not to require such skilful casting as is requisite for turret armour. It would, however, be necessary to set up a special foundry to cast these enormous blocks.

In places of inferior importance, or where a thorough re-construction is not yet authorized, various minor reforms can be carried out. The ditch, of course, can be filled up when there is one. Additional protection is thus given to the ammunition stores, so that there is no longer the risk of having the whole fort blown up by one unlucky shot, and it strengthens the weak point just under the shield. To do this as effectively as possible, the earth should be carried up as high as the sill of the port in the shield. Some will be blown away by firing the gun, but enough will remain to make the protection to the stonework better than if it was not carried above the base plate. It may be noted that these masonry forts, even without ditches, will be fairly secure against assault. They must either be stormed through the ports, which will have shutters or be partly closed by the gun, or over the top, which is 15 feet high, and requires ladders. Where there is no counterscarp, the magazines can be made safer by filling in their outer ends with concrete, and so increasing the thickness. This is better than being blown up, but is not satisfactory in several ways. The ammunition storage is decreased, the protection is not so good as when a sloping service is presented to the projectile, and nothing is done for the masonry under the shield.

In the casemates occasional guns can be removed and the space filled with concrete or some other material, forming a traverse. This would isolate any injury that may be received to a section of the fort.

The fort can be painted in such a manner as to render it less conspicuous, either by being tarred in a band at the level of the top of the shields, as at Hurst Castle, or by being painted in chequers, or in a manner to imitate the background—scene-painted in fact—both of which systems are to be tried at Bovisand.

Notwithstanding these devices though, the sad fact remains that there are a number of masonry casemates that are practically unimprovable. They may have to be kept up for the present as affording the means of fighting guns which may turn the scale in our favour in an attack, but as little money as possible should be spent on them, and they should be looked upon as, in a few years, to be as obsolete as the older works which are often to be found in their neighbourhood.

With regard to the guns and mountings, no alterations are proposed for those which are left in the casemates. Any that are removed will find themselves converted into barbettes giving long range fire.

If the reconstruction with the cast iron blocks, which is to make the casemates proof against the heaviest guns, be carried out anywhere, they would no doubt be eventually re-armed with long BL. guns. The 12-inch of 49 tons is the largest that will go into one of the casemates.

(4). *Continuous Iron-fronted Forts.*—These are few in number, so it is no use generalizing about them. They consist of three forts at Spithead, and one each at Portland, Plymouth, and Bermuda. They all want to be strengthened with additional armour, which can be applied without difficulty when money can be found to pay for it. The works are being armed with 12-inch 49-ton BL. guns on the sea faces, instead of the ML. guns for which they were constructed.

Portland Breakwater Fort is secure with regard to its magazines. Plymouth Breakwater Fort is to be strengthened internally. It is practically impossible to do anything externally owing to the depth of water in which it stands. Fort Cunningham, in Bermuda, has a ditch round it, which can be filled up.

The curved fronted casemates which are intermediate between the masonry shielded fort and the continuous iron front, are also limited in number; there are eight in all. Half of them are pretty secure. Those at Malta have had their ditches filled up. The remaining four are, I think, beyond cure, unless they are removed or set up elsewhere, which it is hardly worth while doing.

(5). *Moncrieff Pits.*—The protection given by these is still good, and from this point of view they do not require alteration.

I have now given you a slight account of the old forms of Coast Batteries; of the causes that led to their being superseded; of the new forms that are taking their place; and of the means by which it is hoped to make some of the old ones still serviceable. I next propose to describe some of the details used in the construction of these works.

It is proposed to consider first some of the details of a coast battery. These may be divided under three main heads; namely, the gun emplacement, including the parapet; the service of ammunition, including ramps, lifts and recesses; and the storage of ammunition. There are also some subsidiary details such as shell-filling rooms and artillery stores.

I shall of course confine myself to batteries of new type only, and shall therefore have but little to say of casemates. The remarks must be understood to refer to open batteries only.

Beginning with the gun emplacement, we will first consider the most important part of it, namely, the pivot and racers and the foundations on which they rest.

Pivots.—For heavy ML. guns, the pivot has usually been formed by an old SB. cast iron gun set in concrete, and connected with the traversing platform by means of a steel pivot plug inserted in the bore. I believe that the supply of cast iron guns is running short, and specially cast pivots are now supplied, as has always been done for the smaller guns.

The function of this pivot was mainly to centre the platform in traversing. It sometimes took up part of the recoil but the intention was that this should be entirely transmitted through the trucks to the racers.

Racers.—The racers for ML. guns are bars of metal—iron for the smaller natures and steel for the larger. They are flanged and resemble somewhat a bridge-rail in section, except those for the 38-ton gun, which are heavier. The racers are usually laid in a groove cut in a ring of stone blocks, and are fixed there by running in a mixture of lead and antimony. In places where stone of sufficient size is difficult to procure, the racers are fixed to iron chairs, of an inverted V shape, embedded in concrete. Great care is necessary in setting racers. The racer blocks must be level, or the necessary support is not afforded to the racer to enable it to resist the shock of recoil. The sinking must be carefully cut, no larger than is absolutely necesary, and level at the bottom. Before fixing the racer it should be laid in the groove, and tested for truth of level and of curve. This can be done by means of a wooden trammel centered at the pivot of the gun, and a spirit level. An error of $\frac{3}{16}$ inch in curve is enough to interfere seriously with the training of the gun. The racer should be bent if much out of truth, or a fresh one demanded. An error in level can be made up by thin packing pieces of iron placed under the racer, but this expedient (and indeed any that leaves an uneven surface under the racer) is objectionable. It is impossible to ensure that the mixture of lead and antimony shall fill up all the hollows under the racers, so as to give it thorough support. The racer should not be finally leaded in, till the platform has been mounted on it and traversed round. This precaution is necessary on account of possible errors in the platform. In the case of racers with iron chairs, the best way of setting them is to make the concrete up to the level of the bottom of the chairs. Then to bolt together the racer and chairs, and to set the whole in place, testing and adjusting for curve and level. When the racer is correct the concrete can be filled in around and under it, special care being taken to use good materials and to see to its being packed well against the ironwork.

Arcs and Racks.—In addition to the racer and pivots, the brass training arcs, used for indicating the lateral training of the gun, have to be laid. These must not be fixed until the gun is mounted and the pointer attached to the platform. Also for some guns iron traversing racks, and, probably, for RML. guns used for long-range fire, steel sweep plates, to take up the vertical shock of recoil, will be required. All these must be fixed with great care in their true positions.

I may illustrate the nature of the shock that the sweep plates will have in part to withstand, by mentioning that an Italian gun recently blew itself in half, on being used as a howitzer. It was made of cast iron with steel hoops; a weak construction, but sufficient for its purpose as a gun; but used as a howitzer the longitudinal strain was too much for it. The sweep plates must, therefore, have the concrete below them strong and with a true surface.

Concrete Drum.—The racers, etc., stand on a drum of concrete, the foundations of which should go down to solid ground at such a depth that no disturbance of the parapet by projectiles can affect them.

The upper portion of the drum, in the case of guns with improved traversing gear such as will be mounted in new batteries, is circular, or nearly so, and rises to a height of 2 feet 7½ inches above the loading way. This portion requires careful construction, so as to be homogeneous and not liable to be cracked or displaced by the horizontal component of the force of recoil.

So far for the old ML. guns.

Racers and Pivots for New BL. Guns.—The new BL. guns are mounted either on a pivot and racer, or on a racer only, or a combined pivot and racer. When the racer only is used it practically takes the part of a pivot as well, the horizontal shock of recoil being transmitted to it through steel clips on the platform.

All these fittings are very much heavier than those used for ML. guns. For instance, the combined pivot and racer for a 9·2-inch BL. barbette, of the Elswick pattern, weighs over 10 tons.

It is evident that the problem of handling this weight is one that requires consideration, and in some situations would be difficult of solution. It is made in two pieces for convenience of transport, but it must be put together before being set.

The racers and pivots are nearly all held down by bolts passing through them and imbeded in concrete. The bolts are of various lengths up to 10 feet.

The exact manner of fixing them must vary with their form and dimensions, but the principle with all is the same. It is to put them together, bolts and all; to support the whole system in its true position, and then to concrete it in.

In the case of the combined pivot and racer, the best method of support is to build up a central column of less diameter than the ring of bolts, and to rest the iron work on it, carefully levelling it. The bolts can then be concreted in, the concrete being carefully packed under the outer edge of the ironwork.

The lighter racers can be hung from beams or rested on rails or girders, the latter being removed before the concrete is finished. With these racers it is probably best, after firmly imbedding the bolts, to remove the racers and to finish off the concrete to a true surface before replacing them; and not to pack them underneath, which is a somewhat uncertain process. The greatest care must be taken to set these fittings level and true, with reference to one another. The finish of the modern gun carriages is considerably greater than that of the old ones, and a corresponding nicety is required in their use. Much better results are of course obtainable.

Concrete Drum.—The concrete underneath these racers is in the form of a drum, as in the case of ML. guns, but there is an essential difference in its function which it is desirable to keep in mind. The whole mass enclosing the holding-down bolts is not really a foundation, but at the moment of firing acts as part of the mounting. That this is the case is evident from the fact that most modern mountings are too light to resist by themselves the shock of recoil without jumping. They are therefore provided with clips on the platform engaging with a clip ring or projection on the racer.

Thus when the gun is fired the mass of the drum is used to resist the upward pull in front as well as the downward shock in rear. There is thus a liability to movement in the drum, and care must be taken that it rests on a solid foundation. It is also imperatively necessary that it should be a well-made homogeneous mass. Concrete varies very often in strength, but the ingredient that has most to do with its goodness is "care in making." You *cannot* give too much attention to this important point.

I have described the mass round the holding-down bolts as a "drum," and such it should be in my opinion. Others think differently, and consider that the mass should be as large as possible, so as to prevent absolutely any movement. I do not agree with this for more than one reason. One is that a very large mass of concrete is liable to crack. Another and more important one is that a slight amount of elasticity and "give," even if quite imperceptible to the senses, will materially diminish the strain on the mounting. It has been found by experience that a mounting may stand the strain of firing at Shoeburyness and fail when removed elsewhere, which is due to the elasticity of the Shoeburyness soil. It is only fair to say that there is a considerable difference of opinion on the question of these concrete masses under the racers. Some authorities would make them as large as possible, as I have said before; others say that the whole system of employing the weight of the concrete mass to resist the upward pull due to recoil is wrong, and that the necessary stability should be obtained by increasing the mass of iron in the mounting itself. They say that it is impossible to count on getting good enough concrete. This view I am unable to agree with. I think that our officers *can* be trusted to attend to this special piece of work when its importance is realized. I think it extremely probable though that unexpected difficulties will arise in some places in connection with these new mountings, and some of you will have an opportunity of investigating interesting problems in mechanics.

A minor point, but one of practical importance, is arranging to keep racers clear of dirt and grit, and in cold countries of ice. Hollows should be avoided as much as possible; when they are necessary they should be drained. A pump may be fitted to clear the large hollows in HP. emplacements of water. The spaces between the ribs of castings should be plugged with Portland cement. There should always be room in an emplacement to get round the mounting, so as to clear the racer and other parts of dirt

In action a good deal of soil is likely to be thrown upon them by shells bursting in the parapet.

Parapet.—The general mass of the parapet should be formed with very flat slopes, as was explained above, if possible not steeper than 1 in 7, so as to deflect projectiles. Its core may be made of any materials available, but from 3 to 5 feet of the upper surface should be formed of sand, or the best substitute for sand that can be obtained in the locality. It is worth while, though, taking considerable pains to get sand, as its resisting powers are extraordinary. Projectiles turn up from it sharply, and even the explosion of a shell will not remove any large quantity. In this it differs widely from clay, which is thrown aside in large masses by a shell. Clay is so bad that it should never be used on the surface of a parapet.

The most important portion of the parapet is that immediately surrounding the gun emplacement. The lower part of this, protecting the drum and the racers, is best made of concrete from 5 to 10 feet thick. Any projectile penetrating so far will probably be checked or deflected by meeting the hard surface. Moreover the support given by the concrete to the earth in front of it will help to cause the shot to deflect. So far things are simple, but with the upper portion of the parapet come a series of difficulties that are not yet completely solved.

The requirements are, to get resisting power against projectiles; strength to resist injury from the blast of the gun; and non-liability to interference with the working of the gun by the displacement of portions of the parapet, or by the projection of fragments into the emplacement.

In the old pattern of barbette emplacement for a heavy gun, the inner portion of the parapet was formed of a concrete wall 8 or 10 feet thick. This was convenient in several ways and entirely met the difficulty about blast, which is a serious one with the old short guns whose muzzles only project a foot or so beyond the crest. Its power of resistance was, however, tested last year at Eastbourne, where a straight section of parapet was built in which the concrete wall was 24 feet long, 6 feet high, and 15 feet thick at the base, sloping back to 5 feet at the top. It resisted two 6-inch shells striking about 8 feet back from the crest successfully, but when the sand was cleared away and the bare concrete struck by a live 6-inch shell, the whole mass was cracked and displaced, and fragments thrown down from it. Although better results might have been expected from a wall curved in plan, as it would be in practice, yet it was evident that the concrete construction alone could not be depended on to resist anything over 6 inches calibre striking near the crest.

The necessity of providing against the effect of blast has, however, led to the retention of the concrete parapet for short ML. guns. The risk has to be taken of injury to the mounting or detachment by displaced fragments of concrete, but a hit must be got near the crest for this to occur, and the target is so small that it may be chanced. The ML. guns in new works are not, as a rule, of the first importance to the defence, nor are they placed in very exposed positions. It is different with the new BL. guns, especially with those mounted on HP. carriages, and more especially with those that have overhead shields, with their edges about 1 foot 6 inches below the crest.

Iron Linings.—Some good results obtained at Eastbourne, when an 8-inch BL. gun was fired against a concrete mass backed by an iron ring, led to the conclusion that this construction was the best for HP. emplacements, and various forms of ring or lining were drawn out. One of these was tried this summer at Lydd, when a live shell from the 8-inch BL. gun penetrated the crest, and showed that this too could not be depended upon.

There are now only two courses open. One is to go on in the direction of iron protection, the other to fall back upon sand.

A satisfactory iron protection would double the cost of the emplacement. This fact alone is prohibitive in many cases, but even apart from this it seems undesirable to adopt this course. It is sinking a large sum of money in a form of protection against a somewhat remote danger, which further developments of the attack may at any moment render comparatively useless. It is not necessary against the smaller and more numerous projectiles, as 10 feet of sand will certainly defect a 6-inch projectile. Hits from heavy shot cannot be numerous, as the rate of fire must be slow and the target is small, being only, so to speak, the rim of the pit, for 20 feet of sand will deflect the shot from an 80-ton ML. gun.

The exact size of the target depends on the angle of descent of the projectile, which in its turn depends on the height of the battery above the sea, the range at which firing is going on, the velocity of the shot, and the slope of the parapet. Batteries should be built on high ground when possible, and the superior slope should be made as flat as is compatable with seeing the water to be defended. A steep angle of descent of the shot means a long range, and therefore increased difficulty in hitting.

Turning to the sand protection, which has the great advantage of not giving off splinters or dangerous fragments, we are met at once by a number of constructional difficulties, of which the first is resistance to blast. An attempt has been made to meet this by tying down the parapet, so to speak, with wire netting. It has not been entirely successful up to the present, but the inventor, Major G. S. Clarke, R.E., is sanguine that he will eventually arrive at the proper proportions of strength and spacing. A form of parapet in which it is used is to be tried this year, both by being fired from and fired at. In this the concrete stops about three feet below the crest, and the upper portion is made up with sand and sandbags, turfed and covered with netting.

This is the present state of the parapet controversy, which has been a very lively one and is not extinct yet.

Concealment.—The question of concealment is an important one in connection with parapets. The long sloping surfaces of modern batteries are invisible in some places and very visible in others, according to the surroundings, but they are almost everywhere necessary. They must, when requisite, be disguised by irregularities of colour and form. The surface must not rise above the lines of fire at maximum depression on each bearing, and must not be much hollowed out, or projectiles will be assisted in penetrating, but within these limits the surface can be roughened. Brambles, and such wild bushes, should be grown. Enonymus and Tamarisk are useful shrubs to plant. Sheep may be allowed to graze on the slopes. They should never be mown unless to harmonize in appearance with meadow land surrounding them. The crest lines between the guns should be made irregular and bushes planted behind it.

The concrete of the gun parapets will be found difficult to disguise. It could be tarred or painted. Mixing ashes with it has been tried, but found useless. I have thought that if made with a dark stone the surface cement might be scrubbed off, in the way that it has been done to the casemate fronts in the new Chatham forts, and the colour of the stone thus rendered visible. There is a field open for ingenuity in this matter.

Storage of Ammunition.—It is better to say what there is to be said on this subject before describing the ammunition service, or supply to the guns.

Cartridge Stores.—Cartridges for all ML. guns of 7 inches calibre and upwards, and for all BL. guns of 6 inches calibre and upwards, are stored in zinc cylinders, which are screwed and lutened down, so as to be air-tight, and are only opened when required for use. They contain the whole or part of a charge according to their size. They are stored standing on end, and can be piled one on top of another, but the pile should not be more than 3 cylinders, or about 5 feet high, or it becomes difficult to move the top cylinders. The floor should be of concrete. No other fittings are required in the cartridge stores. This store should therefore be no higher than is required for movement and ventilation. The accomodation depends on the floor space, and sufficient allowance should be made for passage ways.

At the entrance to a cartridge store must be a shifting lobby, where the magazine men change their clothing, and where all visitors put on magazine shoes. This lobby is divided by a hinged bar of wood, called a barrier, into two portions. In the outer portion the ordinary clothing is taken off; in the inner, the magazine clothing is put on. Nothing that is not allowed in a magazine should pass the barrier.

I hope I have put this clearly. It does not appear to be obscure, but I am sorry to say that shifting lobbies are often built wrong and seldom used right. The principle is simple enough. Nothing that is not allowed in a magazine should go past the barrier, and nothing that *is* used in a magazine should come outside it.

Lamps should not be taken into a cartridge store, but the lighting should be done through glazed holes or recesses in the wall, and a "lamp passage" provided to gain access to them.

Cartridge stores should, of course, be absolutely safe, though in these early days of steel shell and high explosives it is difficult to say what they require to make them so. I should say that for the roofs the minimum should be 4 feet of concrete or masonry and 3 feet of earth. With regard to front protection, it is a great point to get the crown of the arch below the natural surface of the soil, as this is sure to be well consolidated and likely to deflect projectiles. There should be at least 40 feet of thickness in a horizontal direction between the top of the arch and the exterior of the parapet.

Shell Stores.—Filled shell must be stored under cover from the weather, and locked up so that they cannot be meddled with. It is not necessary to protect them against any but direct fire, but it is usual to put them into bombproof chambers alongside the cartridges, for convenience in storage and service. Heavy shell all stand on their ends; floor space, therefore, is what they want. As they may stand on bare concrete, no fittings are required in shell stores. Shifting lobbies are not necessary.

For all bombproof chambers ample ventilating openings should be provided, with the means of closing them in damp weather. A single 9-inch pipe is only sufficient for a very small chamber.

Service of Ammunition.—This is the most important and the most difficult matter to consider in a coast battery.

The rapidity of the fire and the security of the detachment depend mainly on getting the charge expeditiously from the ammunition stores into the gun. The great difficulty is with the projectile when it gets beyond the weight which one man can lift easily. I remember, in old muzzle loading days, a member of the Heavy Gun Committee drew a sketch of "what we should all like to see." It was a 38-ton gun turning its muzzle round for its shot, as an elephant might its trunk. It expressed everyone's feelings exactly.

The service of cartridges is comparatively easy, as they are never made up into portions too heavy for a man to carry. If the ammunition stores are close below the gun, the cartridge cylinder is carried to a lift, which will be described further on, and hoisted up to the level of the emplacement. It is then carried to the gun, and the cartridge is taken out and inserted into the bore, the cylinder being kept closed up to the last possible moment. The empty cartridge case is then passed to the rear, or somehow got out of the way. If the stores are at some distance from the guns, a ramp or passage can be made, allowing the cartridges to be carried right into the emplacement. It is a good plan to end this ramp at a level about three feet below the general level of the emplacement or loading way, finishing it with a vertical wall of this height, not steps. The cartridge cylinder can then be conveniently deposited in the emplacement, and the extra three feet of cover is a valuable addition to the security of the passage. If the cartridge store is a long way from the gun, a supply can be kept in a recess or cupboard close at hand. A recess is very convenient for the smaller guns. One can be made to hold from 25 to 30 rounds of 7-inch ML. cartridges, and the contents of two such recesses might be sufficient for a day's firing.

The projectiles can be brought out when preparing for action, and placed in or near the gun emplacement. It is therefore desirable to provide shallow recesses in the parapet to take a row of shells standing on their bases.

The service of shells from the store, may be either by a ramp or a lift, as with the cartridges. It is advisable to arrange for the possibilty of having to serve shells in action, which might happen if there were not enough sent up beforehand. A ramp for shells should not be steeper than 1 in 7; up this 10-inch shells can be wheeled in a shell truck. This ramp should lead on to the level of the emplacement; or if it end with a rise of three feet, like a cartridge ramp, tackle must be fitted to lift the shells. This would retard the service somewhat, but may be used. The projectile, on arriving at the gun, is hoisted by a selvagee and tackle, attached to a small crane fixed to the side of the platform, and swung up to the gun. It is then entered by hand and rammed home.

Lifts.—In those cases when the ammunition stores are close under the gun emplacements, the shells and cartridges are hoisted by lifts. Of these there are two patterns, the old cylinder lift and the new ladder lift. The old lift is still in use for guns up to 10-inch calibre, or even larger; in fact, whenever a very rapid service is not necessary. It consists of a circular shaft 1 foot 6 inches or 1 foot 9 inches in diameter, and is fitted with tackle differing according to whether it is intended to raise shell or cartridges. For cartridges under 100lbs. weight, a wire rope, taken round a leading block in the floor and an overhead block at the top of the lift, carries a sort of cage in which the cylinders can be placed and hauled up. For heavier cartridges a small winch can be used. For shell, except for those of medium guns, a winch is always necessary. The upper portion of the lift must be at least six feet above the floor to which the charge is to be raised, in order that the shell and cartridge may be easily swung outwards and landed conveniently. Consequently the top of the lift is in many cases not so well protected from fire as is desirable. Moreover, the heavier shell are not raised with so much rapidity as is necessary in cases where they have to be taken straight to the guns for use. And the same thing is the case with some of the new cartridges, which are too long to be placed complete in the cartridge cage, but have to be hauled up in portions.

To remedy these defects the ladder lift has been designed, which can raise either shell or cartridges lying on their sides, and can have several moving up at once. From the different position of its load, this lift only rises about half the height above the floor that the old pattern does, and is then much safer.

Its defect lies in its cost, which is considerable, about £100, but it should be used in all cases where a lift is essential for a heavy gun, and where it has to be used for the supply of ammunition in action.

If recesses can be placed near the guns the old form of lift can still be used, as the recesses, if filled before the beginning of an action, can be kept supplied by steady work with sufficient rapidity.

In all cases where lifts are used there should be an alternative way for transporting ammunition to the emplacement in case of a break down.

Subsidiary Buildings.—In or near a modern battery various subsidiary buildings are required, namely, an artillery store and a lamp room, a bombproof shelter, and a tank; and for a group of batteries, a smith's shop, and sometimes a shell-filling room.

The Artillery Store takes all the small stores of the gun, such as sights and other small fittings, and in the case of breech-loading guns the breech-screws are kept there.

The room should be fitted with a bench along one side, having cupboards underneath, and shelves and hooks on the wall above. From three feet six inches to five feet run of this bench should be allotted to each gun, according to its size. An additional section of the bench should be fitted with a vice, where cleaning and making small repairs can be carried on.

On the opposite side of the store can be hooks for side-arms. Handspikes and tackle are best kept in a store to themselves; but if there are not many all can go into one building. It is always advisable to consult the Artillery before fitting a store. They will be able to tell exactly what has to be provided for the armament to be mounted.

A little room for the lamp-man to keep and clean his magazine lamps in is a great convenience.

Some Bombproof Cover should be provided in every battery that is likely to be at all closely engaged. It will serve various purposes, among others that of a shelter for the wounded, and for men not actually engaged at the guns. A corner might be partitioned off for the telephone, by which every battery should be connected with the officer commanding. A bench under cover from the weather, which might also be in the bombproof, would be a great convenience for the Artillery when at practice. The men have often to stand about for hours waiting for the range to clear, or in bad weather.

A Tank should be provided in a secure situation near every battery. Water is required both for the guns and the men.

A Smith's Shop should be within a convenient distance of the guns, where small repairs to the fittings can be made. As it may be of the utmost importance to repair damages during an action, the smith's shop should be carefully protected from projectiles. It should contain a forge, anvil, and grindstone, and a bench with a vice.

In places of importance, where heavy guns are mounted, a lathe ›r, perhaps, other machines are added, and the room is termed a "workshop."

The question of the necessary requirements of Shell and Cartridge-illing Rooms has for some years been a subject of discussion, but is iow I think in a fair way to settlement by an alteration in the Vlagazine Regulations.

It is intended in future to issue all cartridges made up and ›acked in zinc cylinders ready for use, and to fill all shell at the itation before sending them to the batteries. Ammunition for practice vill be taken from that in store. Cartridges will be taken to a central R.A. Laboratory for examination. Shells will be examined at the ›attery, but any found defective must be taken to the shell-filling 'oom to be emptied and refilled. A convenient shell-filling room nust therefore be provided for each group of batteries, so as to ıvoid transporting heavy shell to long distances. These rooms will ılso serve for filling small shells for battery practice. These new 'egulations, if approved, will render unnecessary the construction of , large number of shell and cartridge-filling rooms, which were ›ssential under the old ones.

Up to the present I have hitherto spoken only of guns, heavy and nedium. Some modified arrangements are necessary when dealing vith heavy howitzers, and with QF. guns of all sizes.

Heavy Howitzers.—There are three peculiarities about heavy ML. ıowitzers, mounted and used solely as such. They are fired only ıt angles of elevation, probably not less than 15°; they have a very hort recoil horizontally, and must therefore be loaded "run up"; ınd they use varying charges of powder.

The form of parapet that suits the first and second conditions is ›ne with a small covered-way running round the front of the mplacement, from which the howitzer can be loaded, the mass orming the protection rising above it, so as to cover both the ıowitzer and the detachment. No sunken way is necessary; in act, it would be inconvenient; so the howitzer can be worked on a evel floor.

The laying is done entirely by position-finder, which will be escribed presently.

The supply of cartridges must be met by having a recess or a mall casemate close by, in which cartridges of various weights can e kept in readiness, so that when called for they can be at once ssued.

Possibly our heavy howitzers will be breech-loaders, in which case the ledge round the parapet will not be required.

Quick-firing Guns.—Quick-firing guns have the peculiarity that they must always retain the firing position between the rounds, and they must be loaded in this position, regardless of the exposure to the men, as otherwise the rapidity of their fire would suffer. Consequently, everything possible must be done to conceal them. This is of much more importance than thick parapets, which are of very little use to them. They might be put into hollows, where they could only be seen when in the proposed line of fire; and they might fire through screens of bushes planted in front of them. A great deal must depend on local ingenuity. When not in action they might be lowered out of view, but this will not help them while fighting.

A space of from six to eight feet radius, according to the size of the gun, is enough for working any QF. gun, so that there is no large emplacement to hide.

The ammunition must be kept handy, at a low level beside the emplacement, so that it may be passed up as required. There is no difficulty in providing for this by means of recesses, as the ammunition is light.

Position Finder.—I will now give a short account of the most important adjunct to coast batteries yet invented, and one which without any exaggeration multiplies several times the value of any gun to which it is applied. I mean the Position Finder, an instrument by which a gun can be directed with the greatest precision on to the spot at which it should be fired in order to strike a vessel, even if the latter be in rapid motion, and which provides for its being discharged at the right moment. Its invention is due to Major Watkin, R.A., who has worked at it for many years, and who has now brought it in its main features to absolute perfection. It passed its final trials with great success last October at Plymouth, where the defences of one side of the harbour have been fitted with it as for service, and it will now be generally applied to all our coast defences.

The details of the instrument are kept secret, but the mode of application and practical working can be described.

The range to the water line of a floating object is obtained by the measurement of the angle of depression to it from the instrument; the base of the triangle to be solved being the height of the position-finder above the water. The direction of the object is observed by something of the nature of a plane-table. So far the matter is quite simple *The* difficulty in designing a position-finder lies in the conversion of this range and direction, as found at the observing station, *instantaneously* into the corresponding figures for the gun, which may be at some distance off, and the equally instantaneous communication of these figures to the gun detachment for use. Any delay is fatal to the chance of hitting a moving object.

In the Watkin's depression position-finder a telescope is pivoted vertically and horizontally, so that it can be directed on to the water anywhere within the field of view. By a perfectly simple but extremely ingenious device, the act of directing this telescope on to the water-line of any floating object indicates on a couple of dials, placed in the battery, the range and training to be given to the gun with which it is connected, in order that its projectile may strike that same object. Thus by the mere act of the observer in watching a ship the gun can be kept directed upon it.

Even this, however, is not sufficient in the case of a moving object, to strike which the gun must be fired in advance. To meet this difficulty a pencil attached to the instrument is made to plot the course of the vessel to be attacked. A prediction can consequently be made of the spot she will occupy in, say, half a minute. The gun is laid to strike this spot, and on the ship coming into view in the telescope it is fired by electricity by the observer. This may sound complicated, but the actual working is simple, and was done by non-commissioned officers at Plymouth with eminent success. It was a very pretty sight to watch the shot from a group of four guns fired together curving down towards the target, and striking the water close to it.

At Plymouth also was shown the successful directing and firing of guns in the Breakwater Fort from instruments on the main land more than a mile away. There are disadvantages attaching to the long interval between the gun and the observer, and they should not be unnecessarily introduced, but this trial has demonstrated that they are by no means insuperable.

The position-finding instrument, as tried at Plymouth, stands on a table four feet long and two feet three inches wide; about the size of a large drawing board. The telescope is pivoted near the centre of the inner side. It is placed in a small building, or cell, partly sunk in the ground, and having a long low opening in front, of such a size as to permit of the telescope covering the whole of the water which could be struck by projectiles from the gun it is serving. The roof is covered with earth so as to assimilate it as much as possible to the rest of the hill side. The heights of the stations above the sea were 250 feet for Bovisand battery, which was close by, and 350 feet for the distant Breakwater fort.

Each instrument is constructed to give the range from a single point, and is therefore useful only to a single gun, unless two or more guns are so close together that their shot will strike a ship when fired parallel, and when they fire over the same water.

This was the case at Bovisand battery, where the guns were grouped in fours.

At the Breakwater the guns are worked singly, having widely divergent arcs.

The instruments tried at Plymouth are constructed to read to a maximum range of about 5,000 yards. A new pattern is being got out for a range of 6,500 yards. This will cover almost all cases of ML. guns as at present mounted. It will be about five feet long by three wide, and will require a proportionately larger building to accommodate it, but can be worked by one observer in the same way as the smaller pattern. For very long ranges up to 10,000 yards, a new pattern altogether will be required, and is being worked out, probably of considerably increased size, and requiring a second operator for the predictions.

For sites which have no ground in their vicinity high enough for the depression position-finder, an old pattern of instrument that works with two observers on a horizontal base will be modernized and employed. Even in its earlier form it proved itself quite efficient, and with the improvements now possible it will be as good as any system can be with two observers.

There will be a good deal of work done in connection with position-finders in the immediate future, and I would warn you that in laying out position-finder stations the great difficulty lies in the uncompromising nature of its requirements as to its field of view, and in the narrow choice of positions that results from it. The arc of view of the instrument *must* cover the arc of fire of the gun up to its extreme range, and there is no give and take possible.

It is well to draw this out on paper before hazarding any but the vaguest speculations as to the sites of the position-finders.

Where several instruments are grouped together, a place should be provided for the commanding officer from which he can watch the action, give directions to the observers, and communicate with the battery by telephone.

This might be a building of the same pattern as those for observing but somewhat longer to accommodate a small staff.

When several batteries combine to defend a channel a central point should also be chosen for the general officer commanding, from which he could communicate with the battery commanders.

The communication between the position-finders and the battery is electric. A cable of seven wires is required for each instrument to work the dials, the firing, and the signals in connection with the latter. Telephone wires are additional.

On land the cable will be laid in a trench at least three feet deep; more in exposed situations. Special attention must be given to bringing the cables into the battery by a secure route. At Bovisand they go down the magazine passage and are brought up the lifts.

The range and training dials, the safety firing key, and other fitting required in the battery, are arranged in a box which can be fixed in any secure position near the gun.

In order to give the gun the range signalled on the dial, an arc and pointer are attached to the gun near the breech, the arc being graduated in yards, calculated specially for the height of that particular gun above mean tide. Other forms of arc and pointer are being tried, and a clinometer attached to the trunnions is used in some cases, but the principle of the graduation is the same—namely that it is given in yards for the particular gun.

The training is given by means of a training arc let into the floor, and graduated in degrees and quarter degrees, and by a pointer attached to the platform. The Royal Engineers have to lay these arcs, and they give a good deal of trouble. They must be laid with all attainable accuracy, but the old platforms do not fit very well, and have a way of getting askew on the racers so that there is a different reading according as you traverse up to a line from one side or the other. The only thing to be done is to take an average of several readings. The new mountings are better in this respect.

The zero line of the training arcs in all new works is to be true north; that is, any gun laid true north should have its pointer at zero, and any two guns whose pointers may be at the same degree are parallel. It will be necessary in every battery to lay down a meridian line, and to take bearings to prominent distant objects which are within the arcs of training of the guns. The number of the graduation at some points in each of the training arcs can thus be determined and the arcs fixed accordingly.

An Inspector General of Fortifications' Circular, No. 516, 2nd May, 1887, has recently been issued on this subject, giving, I think, all necessary information.

It should be remembered that the "cells" containing the instruments depend for safety on concealment. Local surroundings must therefore be carefully studied.

This short description of the position-finder system will enable you to understand its chief features as they affect the Engineers.

Those of you who have to carry out the practical application of it in any of our fortresses will find a great deal of information in the report on the Bovisand experiments, which is now being prepared. It will be very confidential, but will be found at all stations in charge of the Commanding Royal Engineer.

Hints on Designing.—This Paper will conclude with a few hints on how to set about designing a coast battery.

I shall assume that the number and nature of the guns to be mounted have been decided for you, as this is usually, though not invariably, the case.

I myself, when a subaltern, have had to design works without any instructions as to armament or site, and others have had similar experiences. But as a rule the decision as to the number and nature of the guns, and their mode of mounting, will have been settled by inspections and reports of committees, and will have been sanctioned by the Defence Committee and the Secretary of State. All this machinery is so difficult to put into motion that there is very great reluctance to alter any decision once arrived at. However, it may be noted that the most difficult thing to change after final approval is the number and nature of the guns. The sites can be altered for good reasons without much trouble. The mode of mounting can also be changed, but this would be a difficult thing to get passed.

Of course the original settlement of the armament is done by what is practically a rough and rapid designing of the batteries. The nature of the ground at the site of a work usually limits the number of guns that can be placed there, and often prescribes their mode of mounting. But this sort of work is not likely to fall to the lot of young officers, and those who are really capable of doing it well will find the ideas come to them naturally, without any assistance from me.

The first thing to be done in designing a coast battery is to get an Admiralty chart of the neighbourhood, and a map or chart showing the coast line up to the extreme range of the guns, and embracing all the proposed sites for works.

The next thing is to lay down the lines of fire that you would wish to have, remembering that a gun must not fire too close to another except in extreme cases, or when the form of the ground is such as to screen the second gun from the effects of a premature burst of a shell from the first one. This is a matter on which it is desirable to get the opinion of an Artillery officer on the spot. In laying down lines of fire do not waste heavy gun fire by directing it on to shoal water, where strongly plated vessels cannot go, but leave this business to the smaller weapons. Many old batteries are laid out so that the guns fire up to the five fathom line at low water. This is hardly far enough, and the depths at high water should always be considered. Probably the three fathom line at high water should form the limit. It is not necessary to trouble about every little indentation in the coast. Sailors do not like to risk much danger of getting aground.

The lighter guns, or some of them, should command all the water, so that no boats can slip in without being fired at; and the flank guns of a work may fire along the shore so as to oppose any advance by land. No fire to seawards should, however, be sacrificed to this. It is difficult enough to arrange a coast battery to fulfil its own proper functions, and it should not be called upon to do more in its own defence than can be accomplished with machine guns and musketry. Any artillery support that it may require should be provided externally.

Having laid down the desirable lines of fire, the next thing is to go on to the ground and see if they can be got. Sometimes this can be decided at once. Sometimes it cannot be done until the ground has been surveyed, and the battery designed in its general form. At any rate, though, this inspection should be sufficient to decide how much ground should be surveyed on a large scale for the purpose of making the plans. And here let me beg of you not to contract the limits of your surveys. The ground round a fort is equally important to the design as that within it, and it often happens that a somewhat freer treatment of the design than that which was originally contemplated results in a great improvement. Alterations and additions may be made at some future time. Fresh guns or new weapons may require to be placed there. For many reasons a knowledge of the ground near the battery may be most useful, so pray be generous in this matter.

In allotting the sites to the guns, do not be too ready to give them advantages that they cannot make use of.

The highest sites, and those with the best fields of view, must be reserved for the position-finders and the commanding officer. This is to them a necessity. Do not place a gun on ground where it can be attacked from a flank without being able to reply, or where it would have to traverse through an unduly large arc. There is always a temptation to go to the *top* of a hill with a big gun, whereas the best place may often be at one side of the top, where the gun may still get the full arc desired for it, and at the same time be screened from view on one flank. This flank may be exposed to shallow water, or to a channel which has its own means of defence, and with which the gun in question has nothing to do. It should not, therefore, be exposed to the risk of injury from such a quarter.

There is a glaring example of a mistake of this kind at Gibraltar, where a casemate gun having an arc of fire of only 60 degrees has been perched on top of a rocky peak. If it had been placed at the side of the peak it could have been so arranged as not to be seen from the outer flank until its gun came into action. As it is, the casemate can be pounded to bits without the gun firing a shot.

In arranging lines of fire and sites, mind that the flanks of the position are strong. The centre is, of course, the point to be defended, but that need not be done by firing at it. There will usually be plenty of fire there without taking any very special trouble about it. But a favourite naval plan of attack is to begin on one flank and to silence the guns in succession. This must always be kept in mind, and the flank batteries should usually fire outwards.

In laying out howitzer batteries, remember that their fire, at long ranges, is chiefly valuable in keeping ships in motion and preventing them from anchoring, and therefore arrange them to fire over shallow or intricate waters, rather than over deep water free from obstructions, where they would not anchor in any case. I do not think that they will do much at 10,000 yards against a moving object, even with all possible assistance from position-finders. At that range the shot takes about three-quarters of a minute to arrive, and goes half as high as Mont Blanc. In such a journey it may meet with all sorts of disturbing causes.

The next stage in the work is drawing the design, which may be done either at the Station or at the War Office. In the former case, which alone concerns you, it is a little difficult to advise. You must, of course, be provided with drawings of the emplacements, which will have to be adapted to the ground and combined into a battery. Without a good deal more information than I have been able to give in this paper you will not know what is essential in them and what can be altered, and the design will therefore embody unnecessary features, and involve a struggle against unnecessary difficulties. But supposing it has to be done, first place the guns so that they can apparently fire on the lines desired. Then decide on the nature of the ammunition storage and service, whether between or under the guns, and whether with ramps or lifts. Then sketch out the work ; contour the parapets, and make a few sections to see that there is enough thickness of cover for the casemates.

Very likely then you will find that the lines of fire have been interfered with, and the battery must either be twisted round a bit or the levels altered. A process of trial and error must go on till it is got right, and can then be elaborated.

If the plan has been worked out at the War Office, and sent to the Station for application to the ground, it should be carefully criticized to see how it suits the nature of the ground and the surroundings, as these are the points in which it is most likely to fail. The minutiæ of the ground often have a considerable influence in the design. For instance, it is undesirable to place a magazine just where a hard knob of rock comes to the surface, and these points can hardly ever be appreciated from a plan.

Therefore you should look at a War Office plan as probably requiring alteration. At any rate, do not have too much respect for it.

At about this stage of the proceedings it is desirable to set up profiles on the ground, which are a great assistance in realizing the nature of the work to be done.

The deblai and remblai should also now be considered. In old systems a great deal of stress is laid on equalizing them, and, of course, it conduces to economy to do so, but considerations of security and concealment are now of such importance that the other must give way to them. It must be decided, though, where the stuff is to go if not into the parapet, and the amounts must be calculated.

The final process before building is laying out. Here I think the best plan is to mark the positions and levels of the pivots of the guns by building pillars, or in any other way that may be convenient, and refer all dimensions and levels to them. At the same time that you lay out the work, lay out a large scale plan of it, and use it for drawing details and slopes. They must then fit in when executed. I can answer for it saving a lot of trouble in the long run.

Do not adopt the lazy plan of handing the War Office drawing to the foreman and telling him to "go on." If you do, you will get into lots of difficulties, and will deserve them.

J. F. L.

PAPER III.

SAND IN CONCRETE.

By Major H. Pilkington, R.E.

The following concrete experiments were made at Woolwich, with a view of determining the effect of adding sand in the mixing of concrete.

The materials used were:—

	Average weight, per cube foot.	Voids, per cent.
Broken brick	57 lbs.	57
Thames ballast	99 ,,	34
Crushed granite	83 ,,	48
,, slag	74 ,,	51
Beach shingle	98 ,,	37
Sand	95 ,,	22

The brick, granite, and slag were broken in a stone crusher to a two-inch gauge, all the dust and fine stuff being screened out. Some of the hard lumps of slag were found to damage the jaws of the stone crusher considerably. The Thames ballast was clean and of excellent quality; it contained on an average 38 per cent. by bulk of sand.

The beach shingle was from Dungeness. The Portland cement used had a tensile strength of 416 lbs. per square inch (the average of six tests), after setting 24 hours in air, and seven days in water.

The different materials were proportioned in a fixed ratio, independent of the voids contained in each aggregate; and the *Tables* I. and II. show simply the comparative results when they are mixed with cement only, and when mixed with an additional fixed quantity of sand.

The materials for the concrete were measured out on a wood floor, turned over twice in a dry state, and watered through a coarse rose watering pot whilst being turned back a third time, then turned over once more, and immediately deposited in the moulds (deal cases, close jointed), and lightly rammed.

During the mixing the temperature was never less than 45°.

Bulk of concrete produced :—

12 cubic feet of broken brick,		$11\frac{1}{2}$ cubic feet concrete.
4 ,, ,, sand,		
2 ,, ,, Portland cement,		
18 ,, ,, and 12 gallons of water,		

24 cubic feet of Thames ballast, (of which 38 per cent. on an average was sand).		20 cubic feet concrete.
3 ,, ,, Portland cement,		
27 ,, ,, and 17 gallons of water,		

18 cubic feet of crushed granite,		$17\frac{1}{2}$ cubic feet concrete.
6 ,, ,, sand,		
3 ,, ,, Portland cement,		
27 ,, ,, and 16 gallons of water,		

12 cubic feet of crushed slag,		11 cubic feet concrete.
4 ,, ,, sand,		
2 ,, ,, Portland cement,		
18 ,, ,, and 10 gallons of water,		

12 cubic feet of beach shingle,		$12\frac{3}{4}$ cubic feet concrete.
4 ,, ,, sand,		
2 ,, ,, Portland cement,		
18 ,, ,, and 10 gallons of water,		

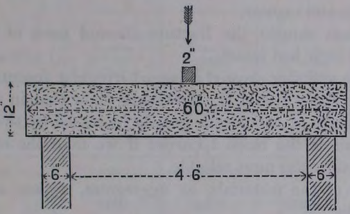
The materials had been kept some time under a shed, and were perfectly dry at the time of mixing and measuring for voids. The water used was just sufficient to thoroughly wet the mixture without allowing the cement to run.

In mixing the concrete where sand was not used the amount of water added was about 30 per cent. less than where sand was used.

The tests were as follows :—

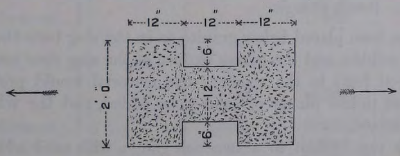
A test. Transverse.

The concrete beams were 6 feet × 6 inches × 12 inches ; width of supports, 6 inches; width of thrust, 2 inches ; distance between points of support, 4 feet 6 inches clear.



B test. Tensile.

Dimensions of beam in centre, 12 inches × 6 inches.



The shoulders were secured in clips, and the beam was torn asunder.

C test. Crushing.

The blocks crushed were all 6-inch cubes.

The tests were made in the Royal Carriage Department of the Royal Arsenal, the machine being that used for testing iron and steel. The arrangement of the machine, which is a very perfect one, allows the strain to be brought on uniformly, and the readings are taken in lbs.

The tests are given in *Tables* I., II., and III.

The general results are somewhat irregular, which is probably due to the smallness of the section used, 12 inches × 6 inches. This could not be conveniently increased, as the weight of the beams, over 3 cwt., made them somewhat difficult to handle, and several were broken before being placed in the machine; the granite and slag appear to be particularly brittle in this respect.

The brick concrete failed by breaking clean through, the fracture being uniform and regular.

In the beach shingle the fracture showed most of the pebbles pulled out of their bed intact.

The granite and slag showed a jagged irregular fracture.

Comparing *Tables* I. and II., the results show that in nearly every case the strength of concrete is greatly increased by the addition of sand; and this is the more apparent if we take the crushing test, which is probably the most reliable.

The value of the materials, as aggregates, appear to be in the following order :—

Thames ballast (clean and of good quality).
Brick, } broken to a two-inch gauge.
Granite, } broken to a two-inch gauge.
Slag, } broken to a two-inch gauge.
Beach shingle.

Slag has been placed below granite, as in the slag tests the fracture was very sudden, and the glassy surface of the slag does not seem to give a good hold to the cement; the material would probably be treacherous unless plenty of sand were added, and the whole very carefully mixed.

Kentish rag, broken to a two-inch gauge, with sand added, gives the highest resistance to crushing when mixed with Portland cement in the proportion of one to four. With less cement it is doubtful whether it would equal good Thames ballast or broken brick; it may probably be fairly classed as inferior to the two latter, but superior to crushed granite.

TABLE I.—Using Sand.

Results of Tests Four Months after Mixing.

Material, measured by bulk.	A Test. Transverse section 12″×6″, 4′ 6″ clear span.	B Test. Tensile section 12″×6″.	C Test. Crushing 6″ cubes.	Average weight of concrete per cubic foot.
	lbs.	lbs.	Tons.	lbs.
6. Broken brick ...	1580	5320	11·383	
2. Sand	1650	4428	12·276	121
1. Portland cement...			Average. 11·829	
6. Thames ballast ..	1325	3400	12·392	
2. Sand	1465	3900	11·785	128
1. Portland cement...			Average. 12·088	
6. Granite	1820	1989	15·482	
2. Sand	150	1149	10·339	138
1. Portland cement...	*	4433	12·035	
			Average. 12·928	
6. Slag	1075	5908	15·089	
2. Sand	*	3189	*	130
1. Portland cement...			Average. 15·089	
6. Beach shingle ...	985	3810	9·375	
2. Sand.	990	3750	9·910	123
1. Portland cement...			Average. 9·642	

* Broken in handling.

TABLE II.—Without Sand.

Results of Tests Four Months after Mixing.

Material, measured by bulk.	A Test. Transverse section 12″×6″, 4′ 6″ clear span.	B Test. Tensile section 12″×6″.	C Test. Crushing 6″ cubes.	Weight of concrete per cubic foot.
	lbs.	lbs.	Tons.	lbs.
8. Broken brick. ...	975	2810	7·272	
1. Portland cement...	970	2415	5·598 Average. 6·435	100
8. Thames ballast ...	1180	2730	8·678	
(Sand screened out)...			5·607	136
1. Portland cement...	820	2840	Average. 7·242	
8. Granite.	650	2200	4·446	121
1. Portland cement...	*	*	6·053 Average. 5·249	
8. Slag	1600	*	6·392	113
1. Portland cement. .	810	*	5·357 Average. 5·875	
8. Beach shingle ...	965	2900	4·915	137
1. Portland cement..	*	*	4·433 Average. 4·674	

* Broken in handling.

TABLE III.

Results of Tests Four Months and Twenty Days after Mixing.

Test :—All cubes six inches subjected to crushing.

Material, measured by bulk.	1st Sample.	2nd Sample.	3rd Sample.	4th Sample.	Average.
	Tons.	Tons.	Tons.	Tons.	Tons.
3. Broken brick ... 1. Sand ... ... 1. Portland cement...	25·5	23·8	22·5	12·2	21·0
3. Thames ballast ... 1. Sand ... ... 1. Portland cement...	30·1	29·2	19·2	18·1	24·1
3. Granite ... ... 1. Sand ... ... 1. Portland cement...	21·2	20·2	15·1	9·5	16·5
3. Slag ... ... 1. Sand ... ... 1. Portland cement...	28·9	27·2	25·9	25·0	26·75
3. Beach shingle ... 1. Sand .. ... 1. Portland cement...	14·5	13·5	12·9	10·5	12·85
3. Kentish rag ... 1. Sand ... ... 1. Portland cement...	35·3	30·0	27·2	23·9	29·1

H. P.

PAPER IV.

MILITARY ENGINEERING DURING THE GREAT CIVIL WAR, 1642-9.

BY LIEUT.-COLONEL W. G. ROSS, R.E.

TABLE OF CONTENTS.

Introductory.

In studying the progressive developments which have taken place in the practice of the art of war, perhaps no period of time, since the application to warlike purposes of gunpowder, is of a more peculiar interest than that which embraces the close of the sixteenth and the commencement of the seventeenth centuries. The Art Military, as practised by European nations, had, by this time, passed through the stage of transition which had succeeded to mediæval modes, and had, in warfare, finally adopted those means and methods which, in all essentials, were to be retained during the course of the two following centuries.

Abroad, on the Continent, the great captains of the age, Maurice of Nassau, and Gustavus Adolphus of Sweden, had, in the first quarter of the seventeenth century, designed and carried out in practice those improvements in organisation, equipment, and tactics, which have made their names famous, and in England, before half of the century had elapsed, their principles and methods were to be accepted and applied during the course of that protracted domestic conflict which has been dignified with the title of the "Great Civil War." For succeeding generations of Englishmen a study of this period of the national history has always been singularly attractive, and great attention has, in consequence, been given to it by students of politics, family history, and topograhpy. Pictorial art, fiction, and poetry, also, have not neglected a field that readily yielded subjects so well fitted for illustration by the pen or pencil. Unfortunately, inasmuch as truth in some of these productions has too often been sacrificed to the supposed exigencies of artistic and dramatic treatment, they do not all merit serious consideration; but their existence and continual appearance prove, at least, a widely spread and enduring interest in the incidents of the great struggle. It is, therefore, somewhat remarkable that, among the many historical works which deal with the Civil War, there should be so few which consider its events from a purely military point of view. No military history of the war, considered as a whole, exists, and of studies of partial extent, few have been written by professional soldiers.

It is true, perhaps, that the strategy and tactics of the combatants are unlikely to afford much of professional instruction to the modern soldier. In tactical matters especially, the changes of late years have been so radical, that the professional student finds himself beyond the necessity of consulting the procedure of a time so remote as the middle of the seventeenth century. But, on other grounds and considerations, one or two of which may be here briefly noticed, an examination of the military history and technics of the time should not be devoid of interest to, at least, the British modern soldier.

To take, for example, a matter of such historical interest as the origin of the British army, it might be shown that the starting point of our present standing army was not—as usually assumed—the force which was embodied at the Restoration, but rather the first army raised, during the war, on the popular side.

The "New Model Army," which commenced its victorious career at the battle of Naseby, itself composed, in part, of troops which had previously fought at the fields of Marston Moor and Edghill, continued to serve successively under Fairfax, Cromwell, and Monk, up to the very time of the Restoration, when part of it was drafted into, and formed the nucleus of, the small force which the king was then allowed to retain as a regular permanent army. This continued service in successive Parliamentary armies of certain military units, which finally were included in the force embodied at the time of the Restoration, constitutes a chain of identity linking all of them together, and admits of a reference of their common origin to the establishment of the first army raised by the Parliament in 1642.

Again, in the interests of general accuracy and historical truth, military studies of this period, by competent professional soldiers, are much to be desired. In attempting any technical study of the war from existing historical works, we are constantly reminded of the incomplete technical knowledge possessed by the authors of some of them, by coming across instances in their works of misconceptions of technical military points and details. When to such shortcomings are added, on the part of the authors, strong partisan leanings—and in the literature of the war nothing is more common than personal bias—the amount of error that may pass into record, and be thereby propagated, becomes a matter of serious moment. It is not too much to say that the disregard, or ignorance, of military details, so frequently exhibited by historians of the War, has led, in some cases, to a mistaken estimate of one or other of the great leaders ; * or, in other instances, has induced prejudiced

* As an instance, take Prince Rupert, whose capacity for organisation and administration, and whose skill in strategy, appear to have received scant acknowledgment. On the other hand his greatest defect, over-impetuosity in action, due probably in great measure to his youth—for he was only 23 years old at the commencement of the war—has been somewhat unduly accentuated.

writers to accept as authentic, or to reject as lacking in authority, contemporary statements and documents, which, tested by the judgment of an unbiassed expert, would have deserved contrary treatment.* It may be granted, therefore, for these and other reasons, on which it is unnecessary here to enlarge, that a military history of the great Civil War is still a desideratum, and a consummation devoutly to be wished. The labour involved in the compilation of such a work would, without doubt, be very considerable. The supposed author—preferably a soldier—would have to make a close and conscientious examination of a vast amount of matter relating to the War, which, widely scattered, exists in manuscript as well as in print. To this study should be brought an unbiassed judgment, and last, and by no means least, an intimate acquaintance with the customs and methods of warfare, as practised at the time, abroad as well as at home. In the examination and narration of the various actions and operations of war, the localities concerned would have to be visited, and personal inspection of the ground would have to be made with the object of verifying and harmonizing the different contemporary accounts of those particular incidents. Such would only be some of the preliminary labours which would be required in the preparation of a carefully compiled and complete military history of the War. It is evident that the suggested work is so considerable in extent, and so encumbered with difficulties of execution, that he would deserve to be considered bold who should undertake the task.

Meanwhile, as a small contribution to the recording of some of the data, which would have to be considered in the course of such a work, the following notes and facts, illustrating the military duties and technical methods of the engineers of the time, are now offered to those who take an interest in ancient history. The plans which accompany them, having been reproduced from originals which are, in most instances, difficult of access, especially form a contribution to the military history of the War which would appear to be worthy of record. To such as are infected, in any degree, with the antiquarian spirit, they will be interesting as records of the past history of the places represented, and although in some of these places much change, since the time of the Civil War, has taken place, in others there still

* The internal military evidence against the authenticity of the so-called "Squire" papers, so frankly accepted by Carlyle, is not inconsiderable. That this argument against these documents should never (as it would appear) have been advanced, is an additional proof of the indifference to, or ignorance of, military matters displayed by so many writers.

remains a great deal which can be traced and determined by a visitor who may wish to follow, and realize more vividly, the incidents of the time. The white battlements of York, and the red walls of Chester, continue to appear much as they did during the sieges of those cities in the years 1644 and 1645; the names of existing streets in other towns, and the ruins of many a famous stronghold all over the land, still bear silent witness to the history of a stirring time; while, as at Basing and Newark, here and there are yet to be seen the actual ramparts and siege works, thrown up during the defence and attack of some old castle or town.

Such spots have more than a mere technical interest to all of English descent. For before these battered and now crumbling walls, and within the enclosure of those grass-grown and fast-disappearing mounds, we stand on ground on which much good English blood has been spilled, and where many heroic deeds have been performed by those who, whether they hailed and replied for "King and Parliament," or for "The King" alone, were not the less our own kith and kin.

General Remarks on Military Engineering.

To Military Engineering, as well as to other branches of the Military Art as practised in England during the seventeenth century, the general remark applies that the methods employed were essentially those used and originated by foreigners. Among authors of military treatises, produced at this time, but few are found with English names, and works written in English are, for the most part, professedly translations, or adaptations, of those compiled by foreigners.

During the fifteenth and sixteenth centuries, Italy, which had been, since the introduction and application to warlike purposes of gunpowder, the theatre of an almost continual warfare, had produced a large proportion of the writers and practical engineers whose names and professional attainments were widely known in the civilized world. The names of Martini, Maggi, Castriotto, San Michele, Pacciotto, and others, will occur to all students of the Art of Fortification, while artists of reputation as Leonardo da Vinci, appear to have considered it within the proper functions of their art to be designers and practical exponents of the art of military architecture. Italian engineers, indeed, were, during the sixteenth century, in so much esteem, that they were employed in other countries, even so far away from home as in England, where, by Henry VIII. and Elizabeth, they were commissioned to build fortifications at some of the principal sea ports of the kingdom.

Towards the end of the sixteenth century, however, engineers of the "Low Countries," or Netherlands, owing to the intimate relations that then existed between those countries and England, began to come into favour in the latter kingdom, and France, and Germany also, about the same time, produced several artists of reputation, whose influence on English practice, as exemplified during the Civil War, was not inconsiderable.

As no national school of design in military architecture existed at this time in England, we have to seek for the models of the fortifications, constructed in this country during the sixteenth and seventeenth centuries, in the systems put forward by foreign engineers. The treatises on fortification written by foreigners were, in some cases, translated by Englishmen soon after their appearance, and consequently afford to us some indications of the comparative influence exercised by the different foreign schools, on the English practice of the time. Immediately before, and during the Civil War, the school of military art which appears to have most influenced English procedure was, undoubtedly, the so-called Dutch* school. In a less degree, but still considerably, the influence of the French school may also be traced, owing, in some measure, to the fact that many Frenchmen served on the Royalist side, as the Queen herself, a daughter of Henry IV., was a Frenchwoman. We find recorded, therefore, in the annals of the War, the names of several Flemish or Dutch, and of some French engineers, including, among the former, the occasional mention of a German engineer.

The foreign practice of the time may be ascertained, either by consulting the original foreign works, or the translations and adaptations compiled from such works by Englishmen, who, though native born, were in most instances educated in the military art abroad. There is this advantage in consulting the translations rather than the originals, that the authors of the former naturally look at things from an English point of view, and not infrequently, in the course of explanation, make references to details which, in connection with

* It is necessary to remember that at this time "Dutch," a translation in fact of "Deutsch," was applied to Germans as well as to the people of the Netherlands. Moryson in his "Itinerary" (1617), speaking of the Netherlands, says, "The people for language and manners hath great affinitie with the Germans, both being called Dutchmen by a common name" (par. 3, p. 91).

English practice, are not only interesting, but instructive. Before proceeding further, therefore, it is as well, perhaps, to record here the particulars of those works written by Englishmen, and dealing, in greater or less degree, with the art of the military engineer, which it is proposed to take as guides during the course of the present enquiry. It is necessary to include in this list the works of authors published some little time after the War, as well as those which were brought out either before or during the War. For the former, written in many instances by men who had themselves served either in, or about the time of, the Civil War, frequently contain allusions to the practice and incidents of the War, which throw valuable light on the history of its military procedure and usages. As far as possible the works are here entered chronologically, though such an arrangement is not necessarily a fair criterion of the actually contemporary character of each of them. For more than one edition exists of some of them, and others were not published for some time after they were compiled.

English Works dealing with Military Engineering.

Francis Markham wrote "The Five Decades of the Epistles of War," 1622. This appears to have been a more original work than some of the others about to be mentioned.

Robert Norton, "One of his Majesty's Gunners and Engineers," wrote "The Gunner." There are editions of 1628 and 1643.

Henry Hexham translated in 1638 Marollois' Work on Fortification. He himself had been a quartermaster under Goring in the Netherlands. It is very probable that he served during the Civil War, as Goring brought over many officers from the Continent at the beginning of the War. This work is one of the most important for a study of the methods of the time.

Robert Ward, "Gentleman and Commander," wrote the "Animadversions of War," 1639. A very complete and profusely, if quaintly, illustrated treatise on the whole military art.

John Cruso.—Wrote many works on military matters, most of which were published at Cambridge. He does not appear to have been a soldier, notwithstanding that he cannot fairly be charged with ignorance of military matters. His principal contributions to the literature of military engineering are contained in: "The Art of War," 1639; "The Complete Captain," 1640; "Castramelation," 1642. Most of his works are translations, or, at best, close adaptations of foreign treatises.

THOMAS RUDD.—Wrote the supplement, dealing with fortification, to the 1659 edition—the first edition is 1650—of Elton's "Complete Body of the Art Military." In the work in question he is described as "Captain Thomas Rudd, engineer to King Charles the First," and rightly so, as there are many notices of his services in this capacity among the State papers relating to the reign of that King.

NATHANIEL NYE.—"Art of Gunnery," 1670.

SIR JAMES TURNER.—"Pallas Armata," essays written in 1670-71, but published, so far as is known, for the first time in 1683.

THOMAS BINNING.—"A Light to the Art of Gunnery," 1676 and 1689.

THOMAS VENN.—"Military and Maritime Discipline," 1672. A very complete treatise. The "Military Architecture" is a translation of Tacquett's work by J(ohn) L(acy).

ROGER LORD ORRERY.—"The Art of War," 1677; this is a useful and even an entertaining work.

CAPTAIN J.S.—"Fortification and Military Discipline," 1688.

In addition to these, the work on Fortification of the Frenchman Antoine de Ville, of which there are two or three editions, may be consulted with advantage, as his reputation, as the leading exponent of the French School of Military Design, gave his writings much influence in the seventeenth century.

Taking these writers as guides, it is proposed to ascertain what were the methods followed by, and the duties expected of, the English military engineer of this time. To this end it will be convenient to consider the subject under the following heads:—

I. Systems of fortifying affected in England, and the character and condition of the permanent defences of the kingdom.
II. Organisation and establishment of the engineer department.
III. Ordnance and projectiles employed.
IV. Duties and employment in field and fortress.

The first three of these will place before us the material means at the command of the engineer, while the fourth will inform us how those means were applied by him.

I. SYSTEMS OF FORTIFYING, AND THE PERMANENT DEFENCES OF THE KINGDOM.

Cruso* groups the whole of foreign practice into four principal divisions, or schools, viz.: French, Spanish, Italian, and Dutch.

* "Art of War."

The French method of constructing the trace he describes as follows:—

In polygons of less than nine sides the flanks of the bastion were usually drawn at right angles to the face of the bastion, so that the shoulder angle was a right angle, and the angle of the flank with the curtain became an acute angle. In other cases, however, the flank might be drawn perpendicular to the curtain.

The lengths of the lines of defence ranged from 200 to 240 yards, these limits evidently depending on the intention of providing a musketry defence for the salient of the bastion. Ward * informs us that the French insisted on the necessity of such a defence for the bastion salient, and, in consequence, did not allow the line of defence to exceed 120 geometrical paces. This distance is equivalent to 200 yards. But he also states that the flanks did not usually defend the faces of the bastions (which statement would appear to correspond with that made by Cruso, that the flanks were drawn at right angles to the faces of the bastions; for in such a construction they could not defend the faces of the opposite bastions), works for that purpose, which he calls "cunes," and "half-moons," tenailles and ravelins, to use modern terms, being provided in the ditch itself.

The Spanish method, according to Cruso, was to have the flanks perpendicular to the curtain, and to provide them, in some instances, with orillons, lines of defence up to a limit of 300 yards being admitted.

Ward generally agrees with these statements regarding the Spanish mode, though he does not admit that so long a line of defence was employed.

According to Cruso, the Italian (Venetian) method of constructing the trace was to work from the interior side of the polygon, and to take the length of this line between the limits of 250 and 330 yards; the lines of defence, in polygons inferior to an octagon, were drawn to points on the curtain, distant from the extremities one-third of its length; in superior polygons they were to meet on the centre point of the curtain.

The flanks, in both cases, were drawn perpendicular to the curtain, and were, in some cases, furnished with orillons.

Ward says the Italian trace was similar to the Spanish, but had larger bastions, and the orillons, when used, had rounded, or, as he calls them, "bouted" ends.

* "Animadversions of War."

Finally, as regards the Dutch system, Cruso says the flanks were always perpendicular to the curtain, the angle of the tenaille invariably 135°, and the faces of the bastion, taken as four-fifths of the curtain, varying in length from 100 to 134 yards.

Ward considers the "Low-country manner" the "most absolutest manner that can be invented." He goes at considerable length into the maxims of the school, and his statement of the case may be thus epitomized:—The salient angle of the bastion was to be as large as possible, the demi-gorges, which were measured on the prolongations of the curtains along the interior side, being at least 50 yards in length. The flanks were to be "fichants," that is to say, the defence of the face of the bastion was to be taken in part from the curtain, the lines of defence meeting on the centre of the curtain, or being directed to points on it distant one-third of its length from either extremity. The former arrangement was to be employed in all polygons superior to a heptagon, and the latter in all inferior to an octagon. In a pentagon, indeed, these points might be fixed at distances from the extremities of the curtains equivalent to one-fifth of their length, and "as for the square figure, it ought not to be put amongst the number of fortresses, and much less the triangle; for they only are to be raised in places of advantage which are strong by nature, or in a camp, or siege of a town."

The flanks, by these constructions, becoming "fichants," were to be made 50 yards long, and, if orillons or "shoulders" be added to them, they should be extended for another one-third part of their length.

The line of defence, that is to say, the line from the foot of the flank to the salient of the bastion, was to be made from 300 to 333 yards in length.

Ditches, or moats, the latter a term usually employed for a wet ditch, were to be 50 yards wide, and further provided with a cunette, with vertical sides, 20 feet wide.

On the counterscarp side of the ditch there was to be an "alley," that is to say, a covered way, 15 feet broad, with a parapet and glacis beyond it.

The ravelins, or "half-moons,"* to have faces of 33 yards, and to be traced so as to be flanked from the curtains; their ditches were to be made at least 20 feet wide, and usually 30 feet deep, the height of the revetment on the escarp side being the same.

* Rudd, in Elton's "Complete Body of the Art Military," says that works before a curtain are called ravelins, while those on the capitals of bastions are called half-moons.

The rampart to have a command of 25 feet; in addition there was to be a parapet, the thickness of which varied, being made 30 feet on the faces of the bastions, but less at the curtains. The width of the terreplein of the rampart was taken at 60 feet.

The "false-bray," an important characteristic of the Flemish method, was to be traced at a distance of 15 or 16 feet from the foot of the rampart, entry to it being given, by means of posterns, at the junction of the flanks and curtain.

Orillons, when used, were to be furnished with an imbracer (embrasure ?) for a piece of ordnance, with the intention of bringing some fire on the breaches usually made at the salients of the bastions.

Revetment walls were made sloping, the rate of slope being as one in three.

Although Ward's account goes into much detail, and fairly represents the Dutch method as it was accepted by English engineers, the description given of the same system in Hexham's translation of Marollois' work is more accurate. As the influence of the Dutch school is an important factor in the practice of the Civil War, this description may be here given in a condensed form.

The salient angle of the bastion varied from 60° in the square, to 90° in the dodecagon; even in superior polygons of a greater number of sides than twelve, it was never to exceed 90°. The diminished angle, in consequence, varied from 15° in the square, to 30° in the dodecagon, being always one-half of the difference between the salient angle of the bastion and the interior angle of the polygon; the angle of the tenaille, also, therefore, varied between the limits of 150° and 120°.

The flanks were invariably taken perpendicular to the curtain.

The lines of defence were not to be longer, for a musketry defence, than 60 rods, equivalent to 240 yards; for a defence by guns their length might be somewhat greater.

The lengths of the face of the bastion, and of the curtain, being fixed at 98 and 144 yards respectively, it followed, in an octagon, that the resulting values of the exterior and interior sides of the polygon amounted to 320 and 240 yards. As the interior angle of polygon increased or diminished, so the difference between the lengths of the exterior and interior sides diminished or increased. By this arrangement the flanks, in superior polygons, became more and more "fichant" as the polygon increased, and the fire brought by them on the faces of the opposite bastions became, in consequence, more direct, while, to a corresponding degree, a larger portion of the curtain was utilized for the flanking of the faces of the bastions. So far Hexham; and such the principal rules of trace advocated by the engineers of the Netherlands. They have been stated here at some length, as it is evident, in examining the plans of works constructed during the war, that they were closely followed by English engineers in the majority, at any rate, of the instances with which we are acquainted.

None of the examples, however, in the plans which have survived to modern times, can be considered instances of more than provisional, or semi-permanent fortification. Of such the enciente constructed round Oxford (see *Plate* VII.) is perhaps the most important, and the influence of the Dutch methods is very apparent, not only in the general character of the design, but in the details of the works themselves; the line of envelope, or continuous counterguard, surrounding the enceinte, being specially characteristic of the school. As will be shown later on,* there is good reason to suppose that the enceinte, at least, was designed by, and executed under, the supervision of an Englishman. Similarly, in the case of the additions to the older enceinte of Portsmouth (see *Plate* III.), which also appear to have been due to an Englishman, and in the design for the second fortification of Liverpool (see *Plate* IX.), due to De Gomme, who was probably a Hispano-Dutchman,† the influence of the Dutch school is very marked. De Gomme, perhaps the most distinguished foreign engineer employed during the Civil War, is thoroughly Dutch in his methods, as may be seen in another of his designs (see *Plate* XV.), for the improvement of the defences at Tilbury Fort. Several designs for this work exist in the British Museum,‡ among a collection of original plans which appear to have been made after De Gomme became Chief Engineer of England, and although the work itself was constructed on another of these designs, the present plan shows what appears to have been the original idea of the designer, and is a good example of the leaning to Dutch methods exhibited by him. The profile given with this design is also instructive, for it shows the fondness of the school for broad, wet ditches, where it was feasible to provide such an obstacle, and the consequent necessity for the employment of a "fausse-braye" to defend the ditch.

* See page 150.
† See an account of De Gomme, p. 110.
‡ See additional MSS., 16370.

From this discussion of the methods which exercised the most marked influence on English practice we may pass to examine the character of the permanent defences which already existed in England, and the condition of those defences at the time of the breaking out of the Civil War.

Anterior to the Civil War there were few places in England that were fortified in a deliberate manner, and such as did exist, for the most part on the sea-board, and at the mouths of one or two of the principal rivers, were somewhat antiquated. Plymouth, Portsmouth, Berwick, and a few isolated blockhouses and forts, were all that England possessed of defences which were of a comparatively modern date. Of all these Portsmouth appears to have most deserved to be considered a modern fortification. Clarendon* tells us that in 1642, when Goring, the Governor of Portsmouth, declared for the King, the Parliament were "put into many apprehensions, as this place had the reputation of being the only place of strength in England." A paper has, not long since, been written in the "Corps Papers,"† which gives much interesting information regarding the growth of the defences along the sea coasts of the Kingdom, and some details regarding Plymouth and Portsmouth are to be found among the notices contained therein. Mr Tregellas's memorandum, however, supplies no information regarding inland defences. Even if such a matter had been within the scope of Mr. Tregellas's enquiry, he would have been at a loss to give an instance of any inland English town, the defences of which, in the early part of the seventeenth century, could be considered to be quite of a modern fashion. Where any defences were to be found at all, they consisted, at most, of the old walls of the middle ages, originally, in some cases, built on a Roman foundation; or of a comparatively decayed castle which, however, as was afterwards to be shown in the course of the War, could be put into a very efficient state of defensibility. It has, indeed, been supposed by some,‡ that when the War broke out there were few towns in England, even among the principal and older ones, which retained, in anything like perfect condition, their ancient walled defences. This idea is probably due to the remarks recorded by

* "History of the Rebellion," Book V. In Book VI. of the same classic he describes Portsmouth as "the strongest and best fortified town then in the Kingdom."

† See "Historical sketch of the Permanent Coast Defences of England," by Walter H. Tregellas, in "Corps Papers," 1886.

‡ See for example Webb's "Civil War in Herefordshire." Vol. i., 136, Note.

foreign visitors of the Kingdom. For example, Frederich, Duke of Wirtemberg, coming to England in 1592, says: "towards night we reached Maidenhead, a beautiful large place or town, but which, like all other English towns, is without walls."* But Ward,† in discoursing of older methods of fortification, talks of "our walled Townes here in England," although he thinks so little of them that he desires, "we may not be deceived in putting our confidence in the strength of them." "We have," he further says, "divers, as Colchester, etc., of the Roman period, with square towers along the walls, and others, as Ipswich and Norwich, with round towers;" "I could wish," he adds, "better Fortifications about some eminent towns near the sea." The fact seems to be, that all over England and Wales, more especially on the sea coasts, and frontiers of Scotland and Wales, there were few important towns without some kind of walled defences; Newcastle, Carlisle, Durham, York, Chester, Bridgnorth, Shrewsbury, Worcester, Ludlow, Hereford, Gloucester, Bristol, Exeter, Plymouth, Southampton, Winchester, London, Colchester, Ipswich, Harwich, Hull, and many others, suggest themselves at the first consideration. Even places situated in the heart of England, where there was little reason to fear an invader, Lincoln, whose walls were said to rival in height those of London,‡ Coventry, of which the same was said by a contemporary soldier§ visiting that place in 1642, and others, were provided with walled defences more or less complete, and capable of being placed in such condition as to offer good resistance.

Wharton, in the letters which have just been quoted, mentions several places, the defences of which, at the commencement of the War, were inspected by him. The walls of Coventry are described by him as being equal in height and thickness to those of London; they were of free stone, and furnished with battlements, towers, gates, and guardhouses; they were three miles in circuit, and of great strength. The walls‖ of Northampton, in September, 1642,

* "England as seen by Foreigners." W. B. Rye, p. 11.

† "Animadversions of War," p. 55, *et seq.*

‡ "Thomason Collection," E 47. 2.

§ Nehemiah Wharton, in some letters to his master in London. See "Archæologia," vol. XXXV., and "Calendar of State Papers, Domestic," 1641–3.

‖ The walls, begun in 1355, took 40 years to build. They were nine feet thick, and were provided with 12 gates, and 32 towers. They remained in good repair for 300 years, and were demolished, in July, 1662, by order of Charles the Second. Three of the gates were still standing in 1830. (Smith's "Warwickshire").

were, however, "miserably ruined;" and those of Worcester also were in disrepair, the "bulwarks" being "decayed;" all that remained of the castle was a mound. In a better condition were those of Hereford, which are stated to have been "better than any I have seen before."

That there were many old towns in England which at this time still possessed walled defences admits of no doubt, and some of the most famous sieges of the War were conducted against such places. We still possess examples of such fortifications in the walls of York and Chester, and that the number which have survived is not greater, is mainly to be attributed to the fact that the party which was ultimately victorious in the struggle dismantled the defences of those towns which had identified themselves during the War with the fortunes of the other side. At the Restoration again came the turn of the Royalists, and Roundhead cities, as in the cases of Coventry and Gloucester, experienced a like treatment. Since that time walls in other places have gradually disappeared. The "iron road," and the growth and extensions of towns caused by its institution, have also done more to remove and conceal remains that were of much antiquarian and historical interest than, perhaps, any other agents.

The hand of the restorer has also been ruthless. At Chester, for example, though we still have the old walls, the gates in them have been 'restored' beyond all necessary requirements, and surely at York it could not have been a *sine quâ non* that holes should be punched in the old walls for the admission of a railway that might very well, in so small a city, have remained outside.

The actual state of such permanent defences as the country possessed at the breaking out of the War was, probably, not very satisfactory. When Charles the First ascended the throne, England had enjoyed a long period of peace; the exchequer was certainly not full, and the want of harmony of views between the Crown and the people was not likely to cause a flow of money to fill it. The defences of the realm were consequently much decayed, and the spasmodic efforts to put them into a satisfactory condition, occasioned by the occurrence of passing panics of invasion by foreign powers, did not produce much result. Mr. Tregellas, in the interesting paper already quoted,* has mentioned some of the measures taken from time to time in this reign, with the view of placing the defences of

* See p. 97.

the kingdom in a more efficient state, and his account may be supplemented by the following notes extracted from the Calendars of the State Papers filed in the Record Office.

Commencing with March, 1628, when the King, among other propositions laid before his Parliament, requested a grant to enable him to repair and equip his forts and castles, as well as to replenish his magazines of stores and provisions,* we have many other allusions to the actual and proposed repairs of His Majesty's forts and castles recorded in the "State Papers."

At length, on the 22nd January, 1635–6, was issued to Lieutenant-Colonel Francis Coningsby, Surveyor of the Ordnance—the Earl of Newport being Master—a commission,† whereby that officer was nominated Commissary-General of all His Majesty's castles in England and Wales, and wherein the duties of the office were very definitely detailed. Once every year the Commissary-General was to inspect the various defences of the kingdom and principality, and to take musters, "by poll," of all the officers, soldiers, and gunners entertained, allowing no "dead pays," "out-livers," or "absentees," to be included in the roll. He was also to see that all instructions which had been given relating to the administration and the equipment of the service had been duly observed, and, further, he was to receive and expend all monies assigned for the purposes of the service, and to render true accounts of their application. In the course of his inspection he was to survey all "decays" of the said castles and forts, and to make the necessary enquiries into any encroachments that might have occurred, furnishing an annual, or biennial, report to the Council and the Treasury. The salary of the office was fixed at 13s. 4d. per diem; in addition there were allowances for the transport of money, besides a permission to retain "dead pays" as part of the salary. A list had been, previous to this, in June, 1635, filed by one Captain John Mason, of all the castles and forts in His Majesty's pay, together with the names of their Captains,‡ and, in the same month and year of its presentation, had been utilized by Secretary Nicholas in the preparation of a revised list, to be retained for reference as occasion might arise.§ And on the 15th of January, 1636–7, an order of the King in Council occurs,|| which directs that the results of a survey made by

* Rushworth, i. 513.
† "Calendar of State Papers, Domestic," vol. CCCXII. 5.
‡ "Calendar of State Papers, Domestic," vol. CCXC. 72.
§ "Calendar of State Papers, Domestic," vol. CCXCI.
|| "Calendar of State Papers, Domestic," vol. CCCXLIV. 2.

the Earl of Newport, assisted by Colonel Alexander Hamilton, and Lieut.-Colonel Coningsby, and visibly appearing in the shape of three books, containing respectively, 1st, the institution of the said castles and forts; 2nd, the remains of the munitions thereof; and 3rd, estimates and statements for their repair; should be taken into consideration, and, for safety, after being copied, kept in the Council chest.* Here, unfortunately, they appear to have remained, and met the common fate of official documents of importance which have been filed with unusual care, for, in October, 1639, we find another order† of His Majesty in Council, made on the petition of Colonel Goring, Governor of Portsmouth, for the execution of necessary repairs to the defences of that town, to which end estimates and surveys were submitted with the petition. These documents coming before the King, His Majesty is "put in mind" of the surveys and reports submitted by the Earl of Newport's committee, and directs that such part of that report as bore reference to the defences of Portsmouth be "perused and considered," before any order were passed on Goring's petition. Something at last, as regards Portsmouth at any rate, seems to have been done, but with unhasting speed, for on the 30th of September, 1640, Goring, apparently, again submits an estimate for the repair of the fortifications of his garrison,‡ and suggests the despatch of Captain Thomas Rudd, "principal engineer for His Majesty's Fortifications."§ Orders, on the same day, are sent to Rudd, directing him to proceed to Portsmouth, and place himself under the orders of the Governor, with the view of not only completing existing works, but of setting new ones in train, for the strengthening of that important garrison. Rudd, as we have before seen,|| was he who wrote the engineering part of Elton's "Complete Body of the Art Military," and the actual work designed by him, and possibly under his supervision, are, as far as the town itself is concerned, in all probability those shown in the plan (*Plate* III.), outside the main ditch of the enceinte on the south and east sides of the town. Whosoever the designer, the works themselves afford another example of the methods of the Dutch school.

To sum up: the permanent defences of the kingdom which were in existence at this time, and which were built in a comparatively

* "Calendar of State Papers, Domestic," vol. CCCXLV. 100.
† "Calendar of State Papers, Domestic," vol. CCCCXXXI. 45.
‡ "Calendar of State Papers, Domestic," vol. CCCCLXVIII. 121.
§ "Calendar of State Papers, Domestic," vol. CCCCLXXIII. 100.
|| See p. 92, *ante*.

modern fashion, were very limited in number, and consisted for the most part of small forts and blockhouses, raised in the time of King Henry VIII., which were situated along the seaboard, or closed the entrances of some of the more important rivers. What their design was may be gathered from the plan of the proposed extension at Tilbury Fort, which shows the old blockhouse, to be retained in the new fort as a species of keep or citadel. Others may be seen in the plan of the fortifications of Hull (*Plate* II.), from which it would appear that there were here three outlying forts beyond the town walls, built along the bank of the river Hull, to guard the most open side of the town. Of more ancient fortifications, there were a good many towns more or less completely walled, and numerous castles and strong mansions scattered over the land in every county of the kingdom. The measures taken for the improvement and strengthening of these defences will be considered later on, as well as certain particulars regarding works of provisional and field types which were constructed during the course of the War. All of these latter classes exhibit, in greater or less degree, the influence of the Dutch school. We now pass to the next sub-head of the enquiry.

II. Organization and Establishments of the Engineer Department.

The close connection which has, till comparatively recent times, always existed, and which, in many military services, still exists, between the two great branches, the Artillery and the Engineer Departments of the Ordnance Corps, was, in the seventeenth century, very intimate. The engineer, as well as the gunner and artificer, were all under the orders of the Master-General of the Ordnance, and were members of the so-called "train" of artillery. In considering, therefore, the establishment appointed for carrying on the duties of the train, it is, at times, difficult to define and distinguish between the special duties required of certain of the individual members of that establishment.

The constitution and organization of the trains of artillery, employed during the Civil War, appear to have been, for the requirements of the time, fairly complete, and were, undoubtedly, based on those fixed by Prince Maurice of Nassau in the service of the Netherlands.

In a list of the train of artillery* employed in the expedition

* Rushworth 2, II., 1046-50, and given in Grose's "Military Antiquities," p. 291, *et seq.*

to the north in 1639 and 1640—a train of "30 or 40" pieces of ordnance—the following items, especially relating to the engineer establishment of the train, occur among the "sundry other officers, artificers, and attendants."

2 Engineers, one at 8s., other at 6s. per diem.

2 Clerks to these, each at 2s. per diem.

6 Conductors of the trenches and fortifications, each at 2s. per diem.

1 Petardier at 2s. 6d.; 12 assistants at 1s. each.

1 Captain of pioneers at 5s.

1 Master smith at 3s.; 6 servants under him at 1s. each.

1 Master carpenter at 3s.; 6 ,, ,, ,, 1s. ,,

1 Bridge maker at 2s. 6d.; 6 ,, ,, ,, 1s. ,,

1 Fireworker at 3s.; 1 assistant at 1s. 8d. per diem.

The master gunner in this establishment received 6s. 8d.; four 'gentlemen' received 4s. each; gunners' mates received 2s. 6d. each; and 30 gunners were each paid at 1s. 6d. per diem.

This train accompanied a force of the other arms amounting to four regiments of foot, each 1,500 strong, and 12 troops of horse, each troop consisting of 100 troopers. The cost of maintenance of the whole force, including the officers of the staff, amounted, in pay, to £442 17s. 8d. per diem, equivelent to £161,652 8s. 4d. per annum, allowing thirteen months in the year.

The establishment of this train is of the more interest and importance as it constituted a model for all those afterwards raised during the war, the customs and usages of the "northern" army being, afterwards, often alluded to when questions of organization were being considered.

The next train to be considered is that of the first army raised by the Parliament in July, 1642. Of this force an efficient list has come down to us in a rare contemporary pamphlet,* which, so far as the engineer department is concerned, supplies the following items:—

* "Thomason Collection," E. 117. 3. The title page is as follows:—"The list of the Army raised under the command of his Excellency Robert, Earle of Essex and Ewe, Viscount Hereford, Lord Ferrers, of Chartley, Bourchier and Louvaine, appointed Captain General of the Army, employed for the defence of the Protestant Religion, the safetie of his Majesties Person and the Parliament, the preservation of the Lawes, Liberties, and Peace of the Kingdom, and protection of his Majesties subjects from Violence and Oppression, with the names of the severall officers belonging to the Army. London. Printed for John Partridge, 1642." Thomason, on his copy of the pamphlet, writes the date of publication as 14th September, 1642.

1 Engineer (John Lyon).
6 Assistant engineers.
3 Captains of pioneers
3 Lieutenants of pioneers.
1 Battery master.
2 Fireworkers and petardiers.
1 Bridge master.
1 Bridge master's assistant.

The master gunner of this train was one Lancelot Honiburne, and there were 18 gentlemen of the Ordnance, who appear to have corresponded to commanding officers of batteries in more modern times.

Lieut.-General De Boys was Lieut.-General of the Ordnance in this train. He is also, in other places, as will be noticed hereafter, described as an engineer, thus giving an instance of the correspondence of duties between the artillery and engineer members of the train. As Lieutenant of the Ordnance he was captain also of a company of 100 firelocks, detailed as an escort for the train. The army, to which this train belonged, consisted of 20 regiments of foot of 1,200 each, three companies of firelocks, and 75 troops of horse, each containing 60 troopers. There were also five troops, each of 100 men besides officers, of dragoons, then considered mounted infantry, and usually spoken of as being in companies. The word 'troop' is used, however, in this Army List.* Among the names of the officers of the staff in this list is to be seen that of John Dalbier, Quartermaster-General. This man was a foreigner—a Dutchman—and one of those professional soldiers who played important parts in the Civil War. He is supposed to have been, indeed, the principal military adviser of Essex, and conducted in chief several of the considerable operations of the war, and among sieges, those of Donnington Castle and Basing House, in 1646 and 1645. The superintendence of engineering operations, in the field at least, seems to have been usually entrusted to the Quartermaster-General's department, for, in more than one instance, officers who held the post are noticed as acting in the capacity of engineers. Symonds, in his diary† tells us that, in 1644, Sir Charles Lloyd, Quartermaster-General of the King's forces, was also considered

* This Army List is particularly interesting, as most of the regiments and troops entered in it fought at Edghill in the first general engagement of the War. See the matter discussed in the "English Historical Review" of July, 1887.

† Harleian and additional MSS., published by the Camden Society.

Engineer-General of those forces. Sir Bernard de Gomme, of whom there will be further occasion to speak, is also mentioned as combining the two offices, and it will be remembered that Hexham, who translated Marollois' work on fortifications, also describes himself, in his work, as a subordinate member of the Quartermaster-General's department, having been employed under Goring in the Netherlands.

The next instance in the history of the War, of the raising of fresh forces on a considerable scale, was the measure carried out by the Parliament in the spring of 1644. A force was then raised for the recruiting of the army embodied in 1642, which, in the course of two years, appears to have been much lessened in numbers. By ordinances of Parliament, dated 1st February and 26th March, 1644, it was decided to raise 7,500 foot in seven regiments, 3,000 horse in six regiments, and a "suitable" train of artillery. These numbers were exclusive of officers. Much discussion, since the beginning of February,* had taken place in committee and between the Houses, as to the details of this ordinance, and this discussion continued till nearly the end of April, when the matter seems to have been finally settled, though minor details connected with the organization of the force crop up afterwards in the "Common's Journals." Only a few details relating to the train of this army are given in the "Common's Journals," and it is possible that such as receive mention represent additions to the existing establishments, rather than a reorganization of the whole train. In May, however, occurs an entry in the Journal of the House, sanctioning an engineer establishment, which would appear to amount to a practical re-organization of the department,† and which was to be as follows :—

1 Chief engineer at 10s. per diem.
1 Clerk to him at 2s. 6d. ,, ,,
4 Engineers at 6s. each ,, ,,
10 Conductors of the trenches at 2s. 6d. each per diem.
5 Miners.
16 Carpenters.
150 Pioneers.

With the exception of the officers of Essex's own regiment, who were to be appointed by the general himself, all officers in the force now raised, including those belonging to the train, were to be nominated by the House itself,‡ and it was ruled that the pay and

* See "Common's Journals" of the time.
† "Common's Journals," 6th May, 1644.
‡ "Common's Journals," 21st March, 1644.

establishments were to be similar to those of the "former establishments of the King's Army in the late Northern Expedition." * A sum of £1,500 was allowed for "setting forward the Train of Artillery,"† and, to meet this charge, £1,000 out of £1,500, then "in the iron chest at Sutton's Hospital," was "borrowed" for three months, and it was further resolved, "that the Chest, or Silver Vessel, in Paul's, shall be sold for the best advantage, and employed towards the providing of Necessaries" for the same service. ‡

Again, in the famous 'New Model' Army of 1645, which, under Fairfax, brought a languishing war to a quick conclusion, we find the following engineer establishment :—§

1 Engineer general.
1 Engineer extraordinary.
1 Chief engineer.
2 Engineers (one of these "Master Lyon").
1 Captain of pioneers.
1 Master gunner of the field.

No details as to artificers and mechanics are given, but these, as well as subordinate engineers and conductors of trenches, etc., must have existed in the constitution of the train. The whole force, of which the establishment formed a part, consisted of 12 regiments of foot, each of 1,200 men; 11 regiments of horse, each 600 sabres; one regiment of dragoons of ten companies, each of 100 men.|| Sprigg mentions, in addition to these, two companies of firelocks for the train, one troop of "lifeguards" for the general himself, and one company of pioneers.

By comparing this list with its predecessor in 1642, it will be evident that a considerable augmentation of engineers had been carried out. There is now an engineer 'general,' one 'extraordinary,' a 'chief,' and two 'ordinary' engineers, one of whom, it may be noted, was the only named officer (John Lyon) in the older list.

As representing the results of experience gained during a constant warfare, extending over three years, the constitution of this particular 'New Model' army is of considerable interest, which is

* "Common's Journals," 25th March, 1644.
† "Common's Journals," 28th March, 1644.
‡ "Common's Journals," 17th April, 1644.
§ Given in Sprigg's "Anglia Rediviva," 1647, p. 325, *et seq.*
|| Rushworth, 4. I. 7. Sprigg, "Anglia Rediviva." Rushworth gives the names of only ten colonels of horse and ten of foot, not including the cavalry regiment of Rossiter, specially included and elsewhere employed, nor the two infantry regiments of Fairfax and Skippon, general and major-general of the force.

enhanced when we look to the actions of its victorious career, and when we consider that part of its troops were, at the Restoration, embodied, as has already been stated, in the small standing army permitted to be retained by the King. Before passing on to the other matters connected with the employment of the engineer establishment, it will not be out of place to gather together here some fugitive notes regarding the individuals whose names, as engineers actively employed during the war, have come down to us. The list, even with the closest research, could never be made anything like complete, but, such as it is, it may be of use to others, who may wish to inquire further in this direction.

Taking, in the first place, the lists that have already been discussed, we find the following names recorded :—

List of 1642.

John Lyon	Engineer.
Edward Frodsham, Henry Roe, John Dungan,	Captains of pioneers.
Gerard Wright, Benjamin Hodson, Thomas Williams,	Lieutenants of pioneers.
Edward Okeley,	Battery master.
Joakim Hane, William Roberts,	Petardiers and fireworkers.
Harman Browning,	Bridge master.
John Herdine,	,, ,, assistant.

New Model Army List.

Peter Manteau van Dalem,	Engineer general.
Captain Hooper,	,, extraordinary.
Eval Tercene,	,, chief.
Master Lyon (see in last list) Master Tomlinson,	Engineers.
Captain Cheese,	Captain of pioneers.

The names of other engineers, being Englishmen, are also to be found, from time to time, recorded in the multitude of 'relations' printed during the war for the information of the public. Such are those of :—

— LANAYON, a Cornishman, employed at Hull in July, 1642.* This Lanayon may be the same as one Lanyon, who is stated to have petitioned in 1660 for a pension of £240, on the grounds of his previous services as "His Majesty's principal engineer."†

CAPTAIN SANDS, of the pioneers, employed in 1644, after the battle of Marston Moor, with a column under Major-General Crawford. While making, at the siege of Sheffield Castle, in company with the master gunner, a reconnaisance, both of these officers were shot.‡

CAPTAIN YOUNG, also of the pioneers, who is accused by one Felton (a brother of him, who, earlier in the reign of Charles I., assassinated the Duke of Buckingham) of 'pirating' a machine called a sow, invented by the said Felton for the assault of fortified places.§

CAPTAIN RICHARD STEEL, "an Oxford Engineere," who, in April, 1644, acting under the orders of Lord Carbery, fortified Milford Haven.‖

MASTER FOGGE, "a Levite," as he is termed by "Mercurius Aulicus," who assisted at the siege of Donnington Castle in 1644.¶ He appears to have been a clerical amateur.

— LANGLEY, taken prisoner in the beginning of 1645, in Hampshire—said to have been an "iron hand." He also appears to have enjoyed, perhaps on account of this hand, the nicknames of "Vulcan," and "The God of War."**

— TOBIAS, killed at Chirk Castle by a stone thrown from the walls. Since this time, says the narrator of his death, such stones have been called "Welch granadoes." For the loss of this "pretious engineere," Sir Thomas Middleton, who was then besieging his own castle, was said to be very melancholy.††

THOMAS LOUP, who, at the Restoration, petitions that he may be continued in the post he had held under the late King. The Ordnance Office report on this petition, referred to them, that of three engineers, "hitherto" employed, the late King had granted to—

* "Thomason Collection," E 108. 40.
† "Calendar of State Papers, Domestic," September, 1660.
‡ "Thomason Collection," E 6. 17.
§ "Thomason Collection," E 44. 15.
‖ "Thomason Collection," E 42. 13.
¶ "Thomason Collection," E 16. 24.
** "Thomason Collection," E 270. 14., and E 271. 4.
†† "Thomason Collection," E 270. 14.

ROBERT DALAMAINE one of the appointments, with £100 per annum out of the Exchequer.* In October, Loup's petition was granted, and he was appointed to the office of engineer, to "attend" the Master of Ordnance and Artillery, with a pension of £100 per annum, in addition to a daily "fee" of four shillings.†

CAPTAIN FAWCETT, who, on the assault of Bristol by the Royalists in 1643, fastened a petard on the Stoke's Croft Gate, and assisted to carry the work—a double ravelin—which covered it.‡

JOHN MANSFIELD, engineer under Prince Rupert at Bristol in 1645. He, with De Gomme, signed the report of the state of the defences at that city.§

There are to be found in the "Civil War Tracts" many allusions to nameless engineers, both English and foreign, employed during the war. One foreigner—another account says a Dutchman—was casting at York, in July, 1642, brass mortars for the Royalists;|| another of his Majesty's engineers in October, 1642, prepared, at Whitchurch, "divers engines;¶ a Frenchman reported "very skilful," but who nearly succeeded, when manufacturing "fire-works," in blowing up the young princes, in the same year and month;** a Dutchman, employed in Exeter, 1642,†† a "very good one," was said to have conducted the party which assaulted Southsea Castle in 1642;‡‡ another, known as "the Devill with one legge," was employed under Waller, at Arundel, in December, 1643.§§

Occasionally, also, there are allusions to the engineering skill displayed by officers whose ordinary duties were not those which were connected with this branch of the services. Sir John Meldrum gained much credit for certain hornworks designed and executed by him at Portsmouth.|| || Colonel Wemyss is styled, on one occasion, "that excellent engineer," and other instances could be given, doubtless, of what may be supposed to have been the amateurs of the

* "Calendar of State Papers, Domestic," August, 1660.
† "Calendar of State Papers, Domestic," October, 1660.
‡ Warburton. "Memoirs of Prince Rupert," II. 243.
§ Warburton. "Memoirs of Prince Rupert," III. The report is printed *in extenso* in the section "The Defence." See p. 148.
|| "Thomason Collection," E 107. 12. and E 108. 35.
¶ "Thomason Collection," E 121. 36.
** "Thomason Collection," E 122. 18.
†† "Thomason Collection," E 128. 11.
‡‡ "Thomason Collection," E 118. 22.
§§ "Thomason Collection," E 80. 8.
|| || "Thomason Collection," E 116. 7.

profession. Wemyss, however, being an artilleryman—see some account of him hereafter—can hardly be considered an amateur. The Reverend William Chillingworth, the well-known divine, who endeavoured to revive and put in practice, at the siege of Gloucester, the moveable machines of attack which had been used in the Roman and early mediæval times, is perhaps the most distinguished example of the amateur* proper.

Some few names of foreigners employed as engineers have come down to us. Perhaps the most eminent of these was Bernard de Gomme (or Gommez) who, with another engineer called Leca Roche, accompanied Rupert to England in 1642.† De Gomme is said to have been born at Lille in 1620, and to have served, in his youth, under Henry Frederick, of Orange. During the Civil War he was attached to the suite of Prince Rupert. On the collapse of the Royalist cause he went abroad with his patron, and does not appear to have visited England till the Restoration, when, having joined the new King at Breda, he travelled over to England in the suite of that monarch. In December, 1660, we find that he petitioned the King for the place of Surveyor-General of Fortifications, formerly occupied by Sir Alexander Hamilton. In this petition are brought forward his services under the late King as "Engineer and Quartermaster-General," a post which had been conferred on him in June, 1645, and renewed to him by Charles II., at Breda, in June, 1649. At the same time he advanced a claim for arrears of pay, amounting to £2,626, for the period of time which had elapsed between the dates of 4th June, 1642 and 4th May, 1646.‡ This petition appears to have been put aside for a time, for we find it repeated in March, 1661, and reported on by the Master of the Ordnance, to the effect that no such appointment or place appears to be entered in the "Tower list," Sir A. Hamilton having acted by special warrant for a time only, and that the "two" engineers' places of the normal establishment were already occupied by other individuals. Notwithstanding this fact, the King granted to Sir Bernard (for De Gomme had been knighted by Charles I.) the post of "Engineer of

* For account of Chillingworth, see Dallaway's "History of Arundel."

† Warburton, III. 232. 4. "De Gomme" appears to have been the name. In the plan of the fortifications of Liverpool (*Plate* IX.) the signature (accurately copied) of De Gomme appears to read "Gommez;" but the flourish may be an "I" for "Inginier."

‡ Assuming this sum to amount to as much as two-thirds of the salary for the four years for which the arrears are claimed, it would appear that the salary of the office must for that time have been about £1,000 per annum; a large one in the seventeenth century.

all the King's Castles, etc., in England and Wales," with a "fee" of 13s. 4d. per diem, the duties of the office being to keep an exact account of all disbursements of money made in the execution of the office. De Gomme continued to be employed in this post, and carried out many designs for defensive work at Sheerness, Portsmouth, Harwich, and other places. Pepys mentions him in his diary, under date 24th March, 1667. At a conference held on the defences required on the Medway, Harwich, "which is to be entrenched all round," and Portsmouth, it is stated that the Duke of York, "advised with Sir Godfrey Lloyd and Sir Bernard de Gunn, the two great engineers, and had the plates drawn before them."

Sir Bernard died in 1685 (23rd November), and was buried in the Tower on the 30th November. No tablet or tombstone recording the event is to be traced, and, as his name does not occur among those of persons buried inside the chapel, it is probable he was buried outside.*

Another foreign engineer of some celebrity, of the name of Rosworm, a German, was employed by the Parliament, but his professional services were confined to a narrower field than were those of De Gomme. He had, previously to the Civil War, served in Ireland, and his first service for the Parliament, for whom he had elected to serve notwithstanding larger offers from their opponents, was the fortification and defence of Manchester against the attack made on that town, in September, 1642, by the Earl of Derby. After this he fortified Liverpool, and the works designed by him are doubtless those ascribed to the Roundheads in De Gomme's plan of the defences afterwards proposed by himself (see *Plate* IX.) He further assisted in person at the siege of Liverpool, after it had been occupied by the Royalists, the siege taking place in 1644 (16th August to 1st November). By January, 1643, he had received the rank of Lieut.-Colonel in Ashton's regiment, the commission being conferred upon him by Lord Wharton. In the same year he

* In the registry of burials, kept in the Tower, the name of Sir Bernard and his wife, Lady Katherine, are both entered as buried in the same year; the former on November 30th and the latter on October 19th. Sir Bernard's granddaughter, Mrs. Boevey, who died without issue in 1726, has a monument in Westmister Abbey, erected by her friend of forty years and executrix, Mrs. Mary Pope. Mrs. Boevey is supposed to have been the original of Sir Roger de Coverley's "widow." The facts relating to Sir Bernard, which have been given in the account of his career, have been taken from various sources. See "Notes and Queries," series II., vol. IX.; "Calendar of State Papers, Domestic," 1660-1; "Illustrated London News," 5th January, 1856; a volume of military plans in King's Library, CII. 21. In this there is a miniature portrait in oil of De Gomme. He has a good-natured expression, grey eyes, and wears a brown wig.

fortified Preston and Blackstone Edge. Notwithstanding his excellent services he does not appear to have been treated with consideration by his masters, as may be gathered from his petition, published in 1649.*

Only the more eminent of the foreign engineers appear to be mentioned by name in the various accounts and relations of the war. Dalbier, the Dutchman, has already been noticed. He afterwards changed sides in the second Civil War, and was killed at St. Neots in 1648.† Philibert Emanuel de Bois (or Boys), an engineer in the Northern Expedition of 1639, and described, on this occasion, as making "great demands," when he stood out for a daily pay of 8s. or 6s. on being ordered to the front in company with Rudd and Lieut.-Colonel Paperill, ‡ was afterwards, in 1642, Lieut.-General of the Ordnance, in the army raised under Essex. In this post, if we may judge from the notices of him that appear in the literature of the war, he does not appear to have given entire satisfaction, having delayed a part, at least of the train, so that it was not present at the first great battle of the war, viz., Edgehill. His employments afford an instance of the close connection that existed at this time between the duties of the engineer and the gunner.

Wemyss, a Scot, is another instance. His early career seems to have been in the service of "the Lion of the North," Gustavus Adolphus, but, in England, he was certainly entertained in an important office some years before the Civil War. In September, 1638, there occurs an order of the council, directing that Wemyss, pending a further enquiry, should continue to occupy a house in the artillery garden, which had for many years past been appropriated to the use of the Master Gunner of England, but which had lately been claimed by the Lieut.-General of the Ordnance. In this order he is styled "Mr. Wemyss, Master Gunner of England." § On the 12th February following, Wemyss petitions regarding his allowance of ammunition for the instruction of "the canoniers of navies, armies, castles, and forts." It appears that the allowance issued from the Tower for the purpose was four barrels monthly, and the "composition" for this allowance came to £72 per annum. But

* "Good service hitherto ill-rewarded," 1649. Given in Ormerod's "Civil War Tracts," Chatham Society. The original tract is of great rarity. Rosworm, in 1659 (July 6), was nominated, by the Committee of Safety, to Parliament as Engineer-General of the Army. "Calendar of State Papers, Domestic," CCIII.

† Peacock's "Army List of the Roundheads and Cavaliers."

‡ "Calendar of State Papers, Domestic," CCCCXVII. 102. and CCCCXVIII. 19.

§ "Calendar of State Papers, Domestic," CCCXCVIII. 50.

this equivalent had been settled when powder was only £2 10s. per barrel, and the price had lately risen to £7 10s., which necessarily entailed much loss to the master gunner.* He prays, therefore, for an increased allowance of money, and, in the course of the petition, incidentally records what are perhaps the most interesting points in it., viz., that, at this time, there were few gunners in the kingdom who understood ranges and the use of mortars, a knowledge of which was a special point in the education of the skilled gunner, and could only be acquired properly by much practice and experience.† On the 30th January, 1639-40, "Mr. Wemyss," Master Gunner of England, is directed to serve for the same pay "as listed last year."‡ From another source it is ascertained that the salary of the office was £300 per annum.§ Soon after the commencement of the war he appears on the side of the Parliament, serving under Waller as his General of Artillery. His engineering talents have already been noticed, and he is generally credited, in contemporary accounts, with the invention of the "leather" gun, although this "nimble piece for the field" would appear to be rather introduced than invented by him.‖ With several of these guns he was taken at the action at Cropredy Bridge (29th June, 1644),¶ and brought before the King, who, receiving him merrily, said he had not yet filled up his place, alluding to the post of master gunner previously held by Wemyss; to which Wemyss is reported to have replied, that his "heart was always with his Majesty." What resulted from this incident does not clearly appear.

In concluding this portion of our inquiry it will be sufficient to record the names of one or two foreign engineers, mentioned among those employed on the Cavalier side.

One, La Roche, who, with De Gomme, came over to England in 1642 with Prince Rupert, still remained in that prince's suite at the end of the war.** Another individual, of the name of Hendrick, evidently a Dutchman, and called a "fireworker," assisted professionally at the first siege of Bristol, when it was captured by the Royalists in 1643.††

* There appears to be something wrong in Mr. Wemyss' calculations.

† "Calendar of State Papers, Domestic," CCCCXII. 91.

‡ "Calendar of State Papers, Domestic," CCCCXLIII. 25.

§ "Military Memoirs of Colonel Birch," Camden Society, p. 87.

‖ See later notice of these pieces in "Ordnance and Projectiles."

¶ "Mercurius Aulicus," E 2. 6., says that on this occasion papers were found in his pocket to show that he had received £2,000 for these guns.

** Warburton. "Memoirs of Prince Rupert," III.

†† Warburton. "Memoirs of Prince Rupert," II.

III. Ordnance and Projectiles in use.

If the ordnance of the reigns of the Tudor sovereigns be compared with that of the times of the Stuarts, little difference is to be discovered. In appearance, calibre, construction, and names, the pieces are essentially the same. We, in the later period, still have culverins, sakers, falcons, and other terms which, taken often from the names of birds of prey, were bestowed on guns by gunners of earlier times. And this nomenclature can be brought down to even later times. So long, indeed, as smooth bore pieces, discharging round shot, continued to be used, there was but little change in artillery armament.

Although before and during the war ordnance was manufactured in the kingdom, the importation of foreign pieces from the Continent was, no doubt, on account of the abnormal demand raised by the War, very considerable. The consequent diversity of patterns and calibres must have been very confusing to the contemporary English gunner, and may, in some degree, explain the very inconstant results and effects of artillery fire, which are recorded in the accounts of the War.

The gunner's art appears at this time to have been in considerable repute, and numerous text books written on the subject, for the most part by practical men, have come down to modern times.

Taking the work* of Robert Norton, "one of his Majesty's gunners and engineers," as our principal guide in all that relates to English gunnery, we find that he divides all ordnance into four main classes, viz. :—

1. Cannons of battery.
2. Culverins and their "consorts."
3. Periors shooting stone or "murthering" shot.
4. Mortars, "murtherers," petards, etc., which are used to shoot stone shot, fireballs, "murthering shot," or "els no shot at all."

The following table, condensed from those given by Norton and Ward in the "Animadversions of War," will supply all necessary information as regards calibres, weights, ranges, etc. Norton subdivides the cannons of battery into various classes: "double or royal," "whole," "demy" cannons, and even "minions" and "drakes," on account of the proportion between their lengths and their calibres, were to be reckoned in this class.

The culverins and their "consorts" included "double," "whole," and "demy" culverins, together with "sakers," "falcons," "falconets," "rabinets," and "bases."

* "The Gunner, showing the whole practice of Artillerie;" Robert Norton, London, 1628 and 1643.

Table of Ordnance used in England.

Taken from "The Gunner" (Norton), pp. 52, 53, and "Animadversions of War" (Ward), p. 109.

Name of piece.	Bore in inches.		Diameter of shot in inches.		Weight of shot in lbs.		Charge in lbs. (Serpentine powder).		Weight of piece in lbs.		Point blank range in paces.		Maximum range in paces.	
	Norton.	Ward.	Norton.	Ward.	Norton.	Ward.	Norton.	Ward.	Norton.	Ward.	Norton.	Ward.	Norton.	Ward,
Cannon	8	8	7¾	7¾	63	64	40	40	8000	8000	360	300	3600	1500
,, Serpentine		7½		7		52		25¼		7000		340		1600
,, French		7¼		6¾		46¾		25		6500		360		1740
Demi-Cannon, eldest		6¾		6½		36⅝		20¼		6000		370		1800
,, ordinary	6½	6½	6¼	6¼	30	32	20	20	6000	5600	312	350	3120	1700
,, smaller...		6		5¾		24½		18		5000		340		1600
Culverin...	5½	5½	5¼	5¼	20	19	16	16	4600	4500	360	420	3600	2100
,, ordinary		5¼		5		16¼		15		4300		400		2000
Demi-Culverin	4½	4½	4¼	4¼	10½	11¾	9	9	2400	3000	348	380	3480	1800
,, lesser		4¼		4		9		8		2300		320		1600
Saker	3¾	3¾	3½	3½	5¼	5¼	5¼	5½	1500	1900	300	300	3000	1500
Minion, or Sakeret	3¼	3¼	3	3	3¼	3¼	3¾	5	1200	1100	240	280	2440	1400
Falcon	2¾	2¾	2½	2½	2½	2⅓	2½	2½	700	750	260	260	2640	1200
Falconet...	2¼	2¼	2	2	1⅐	1⅐	1½	1½	500	400	180	220	1600	1000
Rabinet	1½	1½	1¼	1¼	¾	¾	¾	¾	300	300		150		700
Base	1¼	1¼	1	1	⅓	⅓	⅓	8/3	200	200		100		560

Note.—Ward bases on Smith. Between Ward and Norton there is some discrepancy or confusion in the ranges; the paces in which they each express ranges, do not appear to be the same. Norton states in his work that his pace is the ordinary one of 2½ feet. Ward appears to have used this pace for the point blank ranges, but the double or geometrical pace of 5 feet for the maximum ranges.

on the wall or bulwarks of a vessel, as to receive the greater part of the recoil when the piece was discharged.

This weapon was, in fact, a wall piece fired from the shoulder. It was used in the Civil War, for Ludlow,* who conducted the defence of Wardour Castle in March, 1644, informs us that "a great wall gun, called a Harquebuz de Croq," used by the defenders, burst when being fired.

The harquebus à croc remained in use for long after the Civil War; a military dictionary, of the early part of the eighteenth century, describes it as "a firearm used now only in old castles, and by the French in some of their garrisons; it carries a ball of about three ounces and a half."†

The mortars used at this time were very similar to those which have been employed ever since, and in some cases appear to have been very large, as the example used at the siege of Lathom House in 1644. Birch, in his memoirs, claims to have made the largest in England. This carried a shell of 200lbs. An ancient mortar, long used as a post in Bridge-street, Hereford, which was 15 inches in calibre at the muzzle, is supposed to have been this very piece.‡

One or two curious pieces of ordnance in use at this time may be mentioned. The piece called the "orgue," "organ piece," or "barrel piece," consisted of a combination of several small pieces in one carriage, and is described by Norton. The barrels composing it lay "like organ pypes upon a broad carriage," and were fired by a train arranged so as to ensure a simultaneous discharge.§ These organ pieces carried balls of one pound, or they might be loaded with

* "Memoirs," p. 72. The cause of the bursting of this piece was taken, by the soldiery, to be the result of magic art on the part of a boy, entertained as a turnspit by the defenders, but who had, it was assumed, been bribed by the assailants to "poison" the ordnance of the garrison. The unfortunate youth was made to confess to having poisoned two guns and the wall gun by rubbing the pieces with "poison" of a "red colour," made up "in the shape of a candle." The wall gun having burst, the other guns were again made serviceable "by oiling and making a fire in them." Such were some of the military superstitions of the age.

† "Gentleman's Dictionary," 1705.

‡ "Military Memoir of Colonel Birch, Camden Society," 1873, p. 36, and note.

§ Such a piece was taken from the Royalists at the second siege of Hull in 1643; it consisted of four small "drakes," mounted in a single carriage. (Thomason Collection, E 51, 11). Another instance is mentioned at the storm of Burton-on-Trent, in July, 1643 (E 61, 12). This particular piece is called "a case of small pieces," and it is possible that the term "case," applied so often to drakes, may in some instances be applicable to such a combined and multiple piece.

"pease, leaden, or spelter round shot,"* which would "pierce an armour of proof 12 score yards off at least, being put in a bag or cartouch for each peece." A few of these pieces would "send to the enemie afarre off, a continuall vley† or showre of shot; they are neate and light, for foure of them will not exceed 2,000lbs. weight; and to keep a passage or defend a breach they are of excellent use." The combined barrel piece appears to have been the prototype of the modern machine gun.

Another curiosity was the "trunke gunne," made "like a Fowler but close breeched; * * * * in the carriage thereof, behind, there is a thick elme planke musket proofe with loops (loopholes)," to the end that when "loaded with musket or caliver shott, and fine corne powder, and guarded with two iron or steeled pykes, and on each side of the carriage four long ones fastened, some few of which will exceedingly gall a troop of horse charging, and are easily moved, for two men with their muskets are only needfull."

The petard, included by Norton among the mortar class of ordnance, may be here described, although it is properly more an engineer than an artillery machine. Norton says they were "not unlike a grocer's or apothecarye's spice mortar;" they were of various shapes, "tapered like a cooper's water payle" in some cases, and of various sizes, being charged with from 1 to 50 pounds of powder. For every pound of powder in the charge, four pounds of metal, if made of brass, and five if of iron, were allowed in manufacturing them. Nye‡ testifies to the resemblance that existed between petards and apothecaries' mortars; petards, he says, were "much like unto an apothecarie's mortar, but a great deal deeper." This similitude between petards and apothecaries' mortars, admitted by contemporary military writers, although a perfectly immaterial point, becomes almost of importance when it is found that some modern authors have been inclined to treat with disdain the statement of a contemporary writer that, at least on one occasion during the War, apothecaries' mortars were used as substitutes for petards. Warburton, quoting from a manuscript, relates an incident in illustration of the poverty of the King's resources at the beginning of the War, to this effect: the King being before Coventry, and sending to Prince Rupert, then at Nottingham, for petards, none were to be

* Spelter is pewter or zinc. "Blount Glossographia," also quoted by Skeat, "Etymological Dict."

† "Vley" is evidently "volley."

‡ "Art of Gunnery," 1670, chap. 9.

found in the arsenal or magazine of that town ; at length some apothecaries' mortars were procured, it is said, and having been adapted to the required purpose, were despatched to the King. So far goes the statement of the contemporary manuscript quoted by Warburton.‡ On this statement the author of a well-known and valuable military history, which gives the results of much research, and displays, on the part of the writer, an extensive acquaintance with almost every known source of ancient military information, has the following remark :—He says, "One can only smile at the absurdity of procuring mortars from a druggist's laboratory for artillery purposes."† Had the statements of Norton and Nye been known to this writer, he would not, perhaps, have considered the substitution of apothecaries' mortars for petards so impossible as to dismiss a positive statement, that on one occasion they were so employed, as a palpable absurdity.‡

Another piece of ordnance used at this time deserves notice, on account of the curiosity of its manufacture and construction. It also has been the subject of misconceptions, due to imperfect technical knowledge on the part of those who have described it in later times. The manner of its construction bears a curious analogy to that of a modern gun which has lately been experimentally manufactured with a view to its introduction into the Service, viz., the so-called "wire" gun.

The "leather" gun, it has been shown, was usually ascribed by contemporary writers to the inventive genius of Wemyss, once Master Gunner of England. There is reason to doubt this contemporary belief, however, now, as whosoever was the original inventor, we know that these guns were employed by Gustavus Adolphus many years before the Civil War broke out. Possibly Wemyss, who had served under this Royal General, may have introduced them into the Service in England. There is one example of this gun in the Royal Military Repository, and the dolphins are formed in the shape of the letter "G," which, so far as it goes, is suggestive of the possibility of its having been made for Gustavus. The method of constructing this gun has been erroneously stated by some modern writers, one of whom describes it as being "made of the toughest

* Warburton's "Memoirs of Prince Rupert," I. 110, Note 3.

† "The British Army," Sir S. D. Scott, II., 250.

‡ By boring a fuze hole, and by attaching rings or bolts by which the petard could be attached to its "planchier," or plank, an apothecary's mortar might probably be converted into a small petard with but little difficulty.

leather, and girt with metallic hoops ;"* nor, so far as can be ascertained, is the statement of another writer,† that it could be discharged only seven or eight times, accurate. The example in the Repository consists of a tube, or core, of bronze or brass—not pure copper as supposed by some—about one-third of an inch thick at the muzzle, and probably considerably more at the breach, round which is wound cord, the diameter of which appears to be about one-quarter of an inch, the whole of which is treated with plaster of Paris or some similar material to bind it together. Over the corded tube is shrunk an outer coating of leather, the muzzle, breech, and trunnion pieces being of solid metal, and the vent being bored through the breech piece into the chamber of the piece. These guns are mentioned by some of the contemporary technical writers, and are accurately described by Moore, who says they are made with "soul or chase" of brass, "and then bound about with twine, and outwardly lin'd over with leather for lightness."‡ Allusions to these pieces are not infrequent in the literature of the War. The Scots army, that entered England to assist the Parliament in 1644, was reported§ to be furnished with them, and Colonel Wemyss, "that excellent engineer," it was stated, was bringing these "nimble pieces for the field."|| It has already¶ been shown that they were identified at the time with Wemyss, who, with several of these guns, was captured at Crofredy Bridge in 1644.** Waller, in the same year, had many of them in his train, and at, or before, the battle of Alresford (March, 1644) found their lightness a useful quality in rapid marching through a wooded country,†† the guns being "pioneered" through these woods.‡‡ Their use was continued all through the war, for Massey is found to be manufacturing them in Scotland in 1651,§§ so that there is no doubt that they were considered serviceable pieces in the field.

While on the subject of the "leather" guns, it may not be con-

* "Military Memoir of Colonel Birch," Camden Society, p. 88.

† Harte's "Gustavus Adolphus," introductory essay.

‡ They are mentioned by Turner ("Pallas Armata"), and Jonas Moore ("Treatise of Artillery," 1673). The quotation from Moore occurs at p. 6 of his Treatise.

§ "Complete Intelligencer and Resolver," 2nd November, 1643.

|| "Thomason Collection," E 75, 6.

¶ See *ante*.

** "Thomason Collection," E 53, 18, 38; E 54, 6, 14, "Bulstrode's Memoirs," p. 99.

†† "Thomason Collection," E 2, 20.

‡‡ Clarendon MSS., Bodleian Library, 1738-6.

§§ "Whitlock's Memorials," p. 457.

sidered too wide a digression to note that these and other light guns appear to have been regularly attached to infantry, and even, perhaps, to cavalry bodies. At Roundway Down (1643), an action, in which, on the Royalist side, there was employed a force consisting of cavalry only, there were two guns with the force, which had made a rapid advance to the scene of action from Oxford. The guns must have been not only light, but well horsed, and this fact would appear to indicate, perhaps, the first use of a horse artillery, acting in concert with cavalry. With the infantry regiments of the time, the presence of guns is so often mentioned, regimentally, that it would appear almost certain that there existed a regular system of attaching guns to each regiment. It has been supposed that the system of battalion guns was first instituted in 1686 at the Hounslow Camp,* but there is evidence to show that this system, which was retained in principle till 1871,† was adopted in the English service during the Civil War, if not earlier.‡ The Duchess of Newcastle tells us§ that at Gainsborough, Lord Kingston was slain by a shot from the "regiment pieces" of the Cavaliers. We read also in the letters written by members of certain regiments on service during the War, of "our drakes," as well as of "our regiments." But perhaps the best evidence of the existence of the system is given in the directions for a parade of infantry regiments in Hyde Park in May, 1644, wherein it is ordered, "Let the colonels take their own drakes and carts of ammunition, placing them in van of their regiments, as they march forth," etc.||

The carriages then used for the transport of ordnance were very similar to those still used, or only lately discontinued, having only been heavier and more clumsy than modern gun carriages. In transit a "fore" carriage, or small wheeled limber, was common, and "block" carriages were used for the larger pieces of ordnance. The draught was supplied by horses, cattle, or men using drag ropes; where fore carriages were not available, the shafts for traction were attached to the trail of the gun carriages. The allowance of weight in draught was 500lbs. per horse, 600lbs. per ox, and 60lbs. per man;

* "History of the Royal Regiment of Artillery;" Duncan, vol. I.

† Ibid.

‡ The "case" of drakes, which is so often mentioned in the literature of the War as working with the infantry in the field, may have consisted (taking the analogous term "case of pistols") of a pair of light guns of the drake class.

§ "Life of Newcastle," 1675, p. 44.

|| "Orders to be observed in the march, imbattling, etc., of the citie forces, May 23, 1644." "Thomason Collection," E 49, 14.

the demi-cannon and "furniture" required 100 men, the culverin 40 men, and the "field" piece 30 men to drag them, in each case respectively. The wheels of carriages were very strongly made, no doubt on account of badness of the roads, and were strongly bound with metal and studded on the tires.

There is little to remark regarding the loading and service of the ordnance. Cartridges, though known and used, seem to have been not so much favoured as ladles for introducing the charge. Indeed this old fashion of the ladle was still in use till comparatively late times. The cartridges, when used, were made of fustian or linen, says Norton. Rammers, wadhooks, and sponges with sheepskin heads, were much the same as those now employed. The wads were of "hay, grasse, weeds, okham, or such-like."* In firing, a linstock was used, and fine or "serpentine" powder in the priming, the other sort of powder, of which the charge was usually composed, being called "corn" powder. Windage allowance, as may be seen in the tables, was excessive, and methods of sighting, laying, etc., left much to be desired, the gunner's quadrant, or moveable wooden fore-sights, only being used.

The loading and firing of mortars were rather complicated matters. Over the charge was placed a wooden tampion; on this a green turf; and then the shell with the fuze uppermost. This fuze, invariably it would seem of wood, projected considerably beyond the exterior circumference of the shell. The man who gave fire, held two linstocks, one in each hand; with one he first lighted the fuze, and then with the other he, immediately after, gave fire to the priming. The consequences of a miss fire may be imagined. It is, however, to be noted that at the time when this was the usual method of giving fire to mortars, a writer† of the time says, "the screw hole is to goe next the powder for the better firing it." This would appear to imply that the fuze was to be set in action by the explosion of the charge. Both systems, therefore, the double and single, of firing mortars must have been used at this time.‡

We come now to the projectiles used in ordnance. These differed but little from those which have been employed up to a quite recent

* Norton, "The Gunner."

† Ward, "Animadversions of War," p. 364.

‡ The petard being classed with mortars by Norton, it may be here noted that it was loaded with powder, over which tallow or some similar composition was placed, and then the petard's mouth closed with a stout plank (or "planchier"); to this the petard was bolted or shackled; in firing it was attached or hung to the object and fired by a train.

period. Round shot, shell, and case, were very similar to the corresponding articles as used in modern times. Shrapnell shell was not invented, and stone shot, now obsolete, was then commonly employed. Other miscellaneous kinds of shot, as chain, bar, and bolt shot, and even logs of wood—see the account of the siege of Basing in the Appendix—were obviously, when discharged on special occasions, likely to be effective enough, though logs of wood, at any rate, could only have been used in the event of a deficient supply of shot of more orthodox composition. Red hot shot, and even pieces of old iron heated—as the portions of anchors used at the siege of Lyme Regis in 1644—are often mentioned, *e.g.*, at the sieges of Hull and Gloucester in 1643.

Among the miscellaneous projectiles may be included fireballs, used against buildings and to fire wooden structures made in the attack, and fire-arrows, useful for similar ends. Fire-arrows, as may be seen in technical works of the time, were discharged either from muskets or bows.* Common arrows and musket arrows were also used. A large number of the latter kind were taken by the Cavaliers at the surrender of Essex's army at Fowry in 1644—an episode in the war which, in some degree, corresponds to the great disaster in modern times at Sedan—and are mentioned, among others, by Symonds,† who was, at the time, an officer in the Royalist Army. At the assault of the Brill, in January, 1643, musket arrows were used, and "Mercurius Anlicus," the court journal, describes their fashion of make. They were half a yard long with a head of three inches.‡ But not only when discharged from the firearm is the arrow to be considered a projectile still in use. The long bow had not yet become entirely obsolete for military purposes. Arrows bearing letters and messages were very frequently shot into garrisons beleaguered, and despairing of, or expecting, relief. As related by Gwynne,§ Sir Jacob Astley was on one occasion nearly shot by an arrow, discharged from the town of Devizes. This was not a musket arrow, as it is defined as being a "bearded," or feathered, arrow; falling between Astley's feet, he plucked it out of the ground, exclaiming, "You rogues, you missed your aim." A company of "pikes with bows and arrows" were in existence at Hertford, in

* See for example figures in Smith's "Art of Gunnery," 1643.
† "Symond's Diary," Camden Society.
‡ "Thomason Collection," E 246, 16 and 26.
§ "Memoirs," p. 39.

August, 1642,* and in October, 1643, the King wrote a letter to the authorities of the University of Oxford, recommending the enrollment of a regiment of archers.† Essex himself, in November, 1643, issued what is termed a "precept" for the encouragement of archery, or, as he puts it, the "stirring-up well effected people by benevolence towards the raising of a company of archers for the service of the King and Parliament."‡ Towards the end of 1642 bows and arrows were used to repel an attack upon Bridgnorth, made by the Earl of Derby.§ These instances go far to prove that in English warfare the long bow had not yet become an obsolete weapon.

Hand grenades may be considered with the ordinary "grenade" or shell, of which they were only a smaller kind. Ward‖ says the "grenade" was of two kinds, one for mortars the other for hand service. For "principall service" they were of cast brass, but others, of terra cotta and glass, were also manufactured. All kinds might be used against troops as well as against buildings. Sometimes they were made oval, with a "snowt" or handle opposite to the fuze, and the whole shell was corded over, and when made of clay or glass, anointed with tallow to prevent premature bursting, in the event of there being flaws in the material of which it was composed. Hand grenades were similar to the large shells. When made of metal the alloy recommended was three of brass and one of tin; the thickness of the metal was about half an inch. They were of "the fashion of a pomgranat." In the Repository may be seen glass hand grenades, which are made of a very coarse glass or slag. Under the head of "grenade," Ward also mentions fire-balls and fire-pots. But in the literature of the War the term "grenade" is commonly used to indicate the ordinary bursting shell furnished with a fuze.

Having now disposed of the preliminary heads of the enquiry relating to the means and methods of the engineer, we are in a position to examine his application of those means and methods on actual service.

* "Thomason Collection," E 115, 17. This arm, however, was a special one, compounded of the pike and the bow, as proposed by one William Nead, who obtained a commission in 1633 from the King (Rymer sub anno), sanctioning and ordering the adoption of the combined arm.

† "Proceedings Arch. Institute," Oxford, 1850.

‡ Rushworth, 3, II., 370.

§ "Tourists' Guide to Bridgnorth," 1875, p. 9, quoting apparently from the town records.

‖ "Animadversions of War," p. 363.

IV. Duties and Employment in Field and Fortress.

The Attack.

As regards general principles, the attack, in its various stages, was very similar, in the seventeenth century, to the same operation as conducted since that time. Ward,* indeed, mentions one of three essential considerations, all of which a commander, intending a siege, ought to bear in mind before finally resolving on such an undertaking, which, if ever of moment, is certainly not often attended to now. The General, he says, should consider "first, whether he can derive any right or true title" to the place he intends to besiege. The other two points in the preliminaries to an attack are, however, of as great importance in the present time as they were then. Secondly, he says, a General is to consider whether his force, and the composition of his siege train, are sufficient for the proper conduct of the siege; and thirdly, whether "the profit he shall gain," by the capture of the place, will "countervaile the charge" to which he will be put in carrying out the undertaking to a successful issue. Having resolved himself on these matters, the next step, on his part, was to get accurate information regarding the place attacked and its neighbourhood, after which, "sharpening his valour upon the grindstone of resolution, let him lead his army in good order" against the fortress.

Among the preliminary actions of the forces conducted in so orderly a manner, the first duty required of the engineer was a reconnaissance, carried out with the view of selecting the actual point of attack. Binning would have the gunner to take part in this operation, and, in the absence of a regular engineer, would expect the "experienced gunner" to superintend also the opening of the trenches, and the other operations of the attack in due course.† In the selection of the point of attack, one of the main questions to be decided was whether the attack was to be directed against a bastion, by approach along its capital, or against a curtain between two bastions. This matter was decided by a council of war, called for the purpose.‡ On this point of procedure there appears to have been a great difference of opinion, that of the majority of professional men inclining to the attack on the bastion. This point being settled, the actual attack was to commence.

* "Animadversions of War," p. 79.
† "Light to Art of Gunnery." Introduction.
‡ Ibid.

Venn* says, "there are five Acts proper to the Seige," which are, in order, "circumvallation;" "approaches and batteries;" "sappes or cutting through the out brestwork;" "the gallery;" and "breaching of the bulwark by a mine."

Circumvallation is here used by Venn to represent both lines, interior and exterior, required for the protection of the besiegers against the attacks, respectively, of the besieged, and a possible outer army of observation and relief. Cruso† uses the word in the same sense; Sir James Turner‡ agrees with these two writers. Lord Orrery, however,§ in the work written by him, uses "contravallation" for the inner, and "circumvallation" for the outer, line, and in this application of terms he is supported by modern usage, based probably on the definition of those terms by Vauban, who, in more than one place in his treatise on the attack,|| employs them in the same sense. But a reference to the plan of the siege of Newark in 1845–6 (see *Plate* X.) will testify that "Richard Clampe, Inginier" employed "circumvallation" to mean the interior line enclosing the place attacked.

The explanation of the uncertainty which appears to exist regarding the definite appropriation of the terms, seems to be that, since the early part of the seventeenth century, the practice of employing one of the lines—that against the outer enemy—began to be discontinued, the tacticians of the time preferring, when attacked or threatened by a powerful enemy, to rise from a siege with the object of meeting him in the field, or to employ a second, or observing army, to hold him in check, rather than to fortify themselves and receive his attack in their own lines of investment. It is probable that during the Civil War there was never more than one belt of investing line employed. No mention of a double line has been met with in the accounts of the time, and only a single one is to be seen in the attacks of Newark and Colchester (see *Plates* X. and XIV.). No outer line existed to be forced by the relievers of Newark,¶ or at

* "Military Architecture," p. 42.
† "Art of Fortification," p. 69.
‡ "Pallas Armata."
§ "The Art of War," p. 170.
|| "Traité des Sièges." (Edition Augoyat, 1829), pp. 16, 20, 83, 84; 253–254. But is Vauban correctly translating the original Latin meanings of the words? Cæsar, in the account of the Siege of Alesia ("De Bello Gallico," Lib. VII.), says that after reconnaissance he exhorted the soldiers to work and "Alesiam circumvallare instituit." A little further on he proceeds to say: "his rebus perfectis pares ejusdem generis munitiones diversas ab his *contra* exteriorem hostem perfecit."
¶ Relieved by Rupert, March, 1644.

Basing House,* while, to meet the relieving armies, the Cavalier besiegers rose from the sieges of Gloucester (1643), and Nantwich (1644), and the Roundheads from the siege of York, immediately before the battle of Marston Moor (1644).

The substitute for the outer line seems to have been to fortify the camps, or villages, occupied by the various divisions of the attacking force, so that they were capable of being held against the attack of the outer enemy, and to connect some of these entrenched camps with the line of investment to be held as strong posts in that line. Examples of such attached and detached entrenched camps may be seen in the plans of Newark and Colchester sieges. This procedure naturally led to the use of one term, *i.e.*, circumvallation, for all the works in the line of investment.† As Venn says,‡ "Circumvallation consists in Camps, Trenches, and works of all sorts. The very camps also, being a lesser kind of circumvallation, doe comprehend the two last, to wit, Trenches and varieties of Works." He is, however, careful to point out that both lines might still be employed, for he says,§ "the Lines of the Siege are a continual kind of Rampar, which surround as well the Camp as all the rest of the places about the Town besieged. Concerning these observe this: 1. Let them be two-fold, one inward, built against the besieged, to keep them in, * * * * the other outward, to keep off any enemy that should attaque the Camp from without. Let the outward be stronger than the inward; nay, when there is but a small Garrison in the Town, these inward ones may be spared, or at least very slightly built."

Before describing the "varietie" of works that were comprised in a line of circumvallation, it is desirable to ascertain the meaning of writers when they allude to a certain assumed distance as being a "musket shot" in length.

It is to be remembered that the musket of the period was a heavier piece than the firearm, so called, of later times, being fired off a rest, and with a four-foot barrell carrying a ball of 12 to the pound.‖ Its range, therefore, was probably considerably more than is usually supposed; to supersede the bow so rapidly, as appears to have been

* Relieved by Gage towards close of same year. Both of these actions were most brilliant affairs. The strategical and tactical ability displayed in each instance by the commanders was very remarkable.

† "Bouclement des Places," is the term used by the Chevalier Deville for both lines. See his work on Fortification, pp. 269 and 277, edition 1640.

‡ "Military Architecture," p. 42.

§ "Military Architecture," p. 43.

‖ "English Military Discipline," 1642.

the case, certainly out of England, the range of its bullet must have compared at least not unfavourably with that of the arrow, and this range, we are told by an undoubted authority* was not less than 18 to 20 score of yards when the projectile was discharged by a fairly expert archer. Allowing for some exaggeration—for the intention of the writer of this statement was rather to magnify the advantages of the bow as a weapon—this would represent a range considerably over 300 yards.

As regards the range of the musket, one writer † would have it taken as far as 250 geometrical paces, each of five feet, when the opening of the trenches was about to be undertaken. The words are, "you must know at what distance you may with conveniency break ground * * * * as it is certain the point-blank distance of a piece of Ordnance is 220, 230, 240, 250 geometrical paces, which is also the distance of a musquet shot." The same range is given by Francis Markham ‡ for a musket of foure and a-half feet barrel of the "gage of the Tower of London," the "bastard," or shorter, musket having a range equal to that of the "great" musket. Hexham § somewhat indefinitely lays down that 600 feet is not out of musket range. In a foreign work written towards the end of the century ‖ it is stated that a musket will kill a man at distances over 200 geometrical paces, which is equivalent to over 330 yards, while Hexham¶ would, in permanent works, take his line of defence for an effective musketry fire equal to 240 yards. In the statements here brought together there is evidently some divergence of opinion as to the range of the musket. To harmonize them, it may be assumed that the range of the ordinary musket was taken to be about 250 yards, when a strong supporting fire was required at one given point from another, *e.g.*, from one work in support of another, and that 400 yards or so was the distance beyond which the serious effect of musketry might be diesrgarded. Similarly, "pistol shot" may indicate a range between 120 and 150 yards—for the pistols of the time were long and powerful—"half musket," and "half pistol shot," may be taken as being 150 to 200 yards, and 60 to 80 yards, respectively. That these assumptions are fairly within the mark can

* Neade. "Double Armed Man," 1625.

† Binning, "Light to the Art of Gunnery." Introduction.

‡ Francis Markham, "Five Decades of Epistles of War." 16229 Epistle. First Decade.

§ "Art of Fortification," p. 42.

‖ "Nouvelle Manière de Fortification, etc." 1689. p. 4.

¶ "Art of Fortification."

be shown from the manner in which the works, placed at intervals along a line of investment, were disposed. The distance between such works, as stated by different authorities, varies from 200 to 250 yards, and was evidently that required for mutual effective support between two adjacent works. On the other hand, the distance at which, under ordinary circumstances, ground could be broken without serious loss under the musketry fire of the garrison—400 yards or so—fixes the maximum range of aimed and effective musketry fire.

The line of circumvallation, says Venn, consists in camps, trenches, and works of all sorts. To take the works first. Placed apart at distances of 200 to 250 yards, either in the line itself, or within close distance of it, the works themselves consisted of "Redoubts or little Turrets, middle or toothed defences (ravelins ?), outward and inward angles (indented lines ?), little Tonges (Redans), stars, square forts with whole bulwarks, various forts with half bulwarks, whole plain bulwarks, and half ones, ravelins, half-moons, horn-works, crown-works."* Figures are given by him of the more important kinds, two examples of which are reproduced in the plate of details of siege works (*Plate* I.). To build a redoubt or "turret," continues our author, is "a most easie thing, since their form is simply square." The side of the square he takes at 48 feet, measured apparently along the crest line. "Stars" were constructed on squares, pentagons, or hexagons, but "your larger stars are not in use." Half bulwark forts were described on squares, or rectangles, and even on triangles; in the case of a square fort of this kind the side of the polygon varied between the limits of 120 and 180 feet. A quadrilateral fort, with half bulwarks and "double tonges," is shown in *Fig.* 9. of the *Plate* of siege details. The mode of constructing this work may be given as a typical example :—From the angles (*c*) and (*d*) of the square (*abcd*), lay off along (*cd*), produced (*ci*) and (*dk*) equal to one-third of the side of the square. Make (*cp*) and (*dr*) also equal to one-third of the side of the square. Similarly, (*am*), (*as*), (*bn*), (*bt*) are each equal to the same length. To the sides of the square draw (*px*), (*ml*), (*nv*), (*rz*) at right angles, and each equal to one-sixth of the side of the square. Join (*ix*), (*sl*), (*tv*), (*kz*), and the four "half bulwarks" are obtained. The "double tonge" (*gfh*) is obtained by describing from the centre (*e*) of the side of the square a semicircle, with radius equal to one-third of the side of the square, cutting (*cd*) in (*g*) and (*h*), and the perpendicular at (*e*) in (*f*); join (*fg*) and (*fh*). Hence the angle $(gfh) = 90^\circ$.

* Venn, "Military Architecture."

In a manner similar to this was constructed the trace of a triangular "flanquered" redoubt or "sconce." See *Fig.* 8, *Plate* of siege details. Ward uses different names for some of these works, and his notation is often more in accordance with that which appears to have been commonly used in England at the time. He applies* the term "skonse" to all works with whole bastions constructed on every polygon; redoubts are "framed without bulwarks," while, if provided with half bulwarks or bastions, they become "redoubts flanquered." Half-moons might be either semi-circular or angular as redans. Ward, however, gives no details as to dimensions or methods of tracing these different works.

These works were applied in the defence as well as in the attack, and a reference to the plans here given, and particularly to those of Newark, Plymouth, Colchester, and London, will discover, in the works thrown up at those places, examples of many of those described by Venn and Ward.

For ordinary works of these kinds the section, given in *Fig.* 4 of the siege details, and taken from Hexham, who applies it to the case of a square redoubt or fort with complete bastions, appears to have been that generally used. Smaller works had weaker sections, as shown in *Fig.* 3. In strengthening the more important works obstacles were freely employed; the various kinds of these will be examined when considering the defence.

The trench, or line of circumvallation, which connected works of the kinds which have been described, requires little notice. Its section varied according to circumstances; the section given in *Fig.* 2 is taken from Deville, and may be considered the usual one.

The camps and line of circumvallation having been made sufficiently defensible, the next stage of the attack—the opening of the approaches—commenced. The breaking of ground, then as now, could not, however, be undertaken till the artillery fire of the fortress had been in some degree mastered. To this end batteries, corresponding to those in the modern "first artillery position," had to be constructed and armed. Hexham† recommends that these batteries should be made elevated. His plan for such a battery is reproduced in *Fig.* 5. The parapet might be 20 feet, and must not be less than 12 feet, thick; it might have epaulments on the exposed sides. The platforms were to be of oak planks, and behind

* "Animadversions of War," pp. 38, 39.
† "Art of Fortification," p. 36.

them again, for specially heavy ordnance, hurdles laid on the earth. To get the necessary earth for the construction of the battery, a ditch was carried all round the enclosure, and the magazine, or "cave," was to be placed at the rear, and put under the superintendence and management of a "conductor," for the issue of ammunition and stores. Mantlets were provided for the embrasures of all batteries, those constructed on the glacis having such mantlets made of musket proof plank. In some cases large gabions were used to make the parapets of batteries, and being put in three rows, which broke joints, are stated to have formed excellent protection for the guns; the embrasures in such gabion batteries were obtained by gradually diminishing the number of gabions in the rows in advance of the innermost line. The gabions in use are stated to have been of three sizes: "ordinary," six feet high and three feet in diameter; "middle" size, seven feet by five feet; "double," ten feet by seven feet. Three rows of the largest were usually employed in making battery parapets. The guns of the period requiring seven clear feet on the axles of their carriages, an allowance of eleven to thirteen feet between central lines of embrasures was considered sufficient for their service, and the dimensions of the embrasures are stated, by both Hexham and Ward, to have been two feet at the necks, and four feet at the mouths; the sill was three feet above the platform. The excavated magazine was covered only with raw hides, the danger from sparks, and not from the shells of the defenders, being apparently considered. The batteries in all cases were to be placed close to the trenches, so as to be protected by the guard of the trenches.

These first batteries are stated by Venn* to have been usually "at a musquet shot from the Town," that is to say, not nearer than 400 yards; the "general rule may be this, that the nearer they are the place they do the greater execution."

Venn also mentions what he calls a "defensive battery," *i.e.*, one "directed towards the enemy without." These, being "not so full of work," were to be constructed with parapets of only six or seven feet, and their height was to be limited to what was sufficient to cover a gun and its carriage; that is to say, they were merely epaulments, the guns standing on platforms laid on the natural soil; gabion parapets were commonly used in such batteries.† Screens, in some cases, appear to have been used in front of batteries, with embrasures in the screen as well as in the parapet of the battery.

* "Military Architecture," p. 47.
† Ibid.

Norton fully describes them, though the language employed is somewhat involved.* Curiously enough, they are not mentioned by the other writers who have been consulted. The batteries of the first position were armed with culverins, the special function of the ordnance being to reduce the guns of the defence. In close proximity to the group of first batteries, a "sconce," or redoubt, also often called a "corps de garde," or "court of guard," was erected at, or near, the point where it was intended to break ground for the trenches or approaches of attack. Hexham † would have this work to be made square, with a side of 16 to 24 yards. It was considered advantageous to have these works completed in one night. They were so traced as to "enfile" the approaches, being usually placed so that the direction of the diagonal of the square coincided with the prolongation of the line of approach. If the branches of the approaches were long, intermediate works of the same kind were introduced, but ordinarily they were placed at the point of junction of two branches, so as to enfilade both. ‡

The next stage of the attack was the advance by approach on the fortress. At one time it had been the custom to employ civilian labour for the "breaking of ground," but the Prince of Orange had succeeded in overcoming the objections of his soldiery to perform excavator's work, by establishing a system of working pay, and during the Civil War this custom appears to have been followed in the English service. We are told by Nehemiah Wharton that Essex paid his troops 12d. a day at the fortification of Worcester.§

In breaking ground it appears to have been the duty of the captain of pioneers to raise the first turf ;|| the work was commenced, under ordinary circumstances, about 400 yards from the place attacked. Venn says¶ not nearer than 1,000 feet, Hexham and Cruso say not nearer than musket shot nor further than "harquebuze à crock" range.** The working parties were composed of "commanded" men, or parties detailed out of each regiment employed at the service. As many as 400 or 500 were taken from each regiment, equivalent usually to one-third of their full strength. Working

* Norton. "The Gunner." p. 115.

† "Art of Fortification," p. 33.

‡ Venn, Turner, Hexham, etc.

§ "Archæologia," vol. xxxv., and "Calendar of State Papers, Domestic," 1641–3.

|| F. Markham. Decade 4. Epist. 3.

¶ These distances, respectively, may be taken to be 400 and 600 yards.

** Probably about 600 yards.

parties so large would imply that the excavators were extended, as is now the custom, along the line to be excavated, but with the exception of Hexham (who is the authority for the statement just given), most of the other writers, who go into the details of the operation of opening the approaches, specifically state that the advance was made by the men working, as is now done in sapping, in file, and not in extended line. Binning,* however, supports the extension, and explicitly mentions that the diggers were extended at four, five, or six feet intervals, and excavated a first task of three feet wide and deep. If the point of commencing operations was distant from the camps of the besiegers, strong guards of the trenches, and covering parties, were detailed to protect the workmen †, The usual section of the approaches has been already noticed. Some writers would have them to become of greater depth the nearer the advance approached the fortress, in order to protect the interior of the trench from the effect of a more plunging fire.‡

The zigzags were directed clear of the work attacked, so as to avoid being enfiladed, and advanced, by alternate changes of direction at every 300 to 500 feet, on the fortress, protected by redoubts and batteries. In some cases advance was made directly, and not by zigzags, and in such a case the approach became practically a double standing sap, traversed with gabions, and so blinded as to protect, and defilade, the approach. For the protection of the head of such an approach we hear of "blinds," and Ward§ mentions an "engine," called the "Saulcisse," of which he gives a figure, and which he describes as made of wood and iron hoops, "in manner of a Hogshead or Pipe," and filled with "Dunge or Sand," which was, in fact, a sap roller. For this "engine" did "wonderfull service" when "alwayes rowled before those that went to intrench themselves."

And so proceeded the attack, till having reached the counterscarp or crest of the glacis, || or till the time had arrived when ordinary advance became impracticable,¶ the sap was resorted to. For a figure illustrating the attack procedure, see *Fig.* 1 of the *Plate* I. adapted from Hexham.

* "A Light to the Art of Gunnery." 1689. Introduction.
† Hexham. Cruso. "Art of War," p. 69.
‡ Binning, *ut supra*, prefers to place the supporting redoubts 10 yards clear of the trenches, and not in them.
§ "Animadversions of War," p. 373. Norton, in the "Gunner," p. 132, mentions "saussons," "saucidges," "candlesticks," and "blinds."
|| "Pallas Armata," p. 316.
¶ "Art of Fortification." Hexham, p. 36.

The "zappe," says Turner was nothing else "but a digging," but "men have appropriated it to that digging which is near to, or in the Counterscarp."* The work was done kneeling, the tasks being three feet wide and deep. Hexham says they may be made from three to six feet deep, according to circumstances. After the covered-way was crowned, galleries were driven, and to attach the miner to the face of the bastion, a covered gallery was taken over the ditch. Breaches were effected by mines, or by guns, or by both combined.† During the War, breaching by mines seems to have been the usual plan, though breaching by guns is not uncommon, and in some few cases, as at the second siege of Wardour Castle (March, 1644), the primitive method of underpinning with timber the wall attacked, and then setting fire to the props, seems to have been employed in combination with the more modern way of using powder.‡ In driving the galleries from the lodgments on the glacis or counterscarp, their slopes were arranged so as to bring them out on the face of the counterscarp revetment at the water's edge if the ditch were wet; "the brinke of the moat," says Hexham.§ If the ditch was dry, the point of exit of a gallery depended on the level at which it was intended to pass the gallery over the ditch.‖ The gallery of descent was made six, or more, feet high, and five or six feet broad; the section of that which was taken across the ditch was greater, being seven or eight feet high, and six or eight feet broad.¶ To give it a proper foundation, the ditch was filled up with faggots and brushwood,** or earth in sacks, sandbags, etc., the result being a dam, or causeway, on which the gallery of transit rested. This gallery was provided, on the exposed side, with a shot-proof wall of timber, made of uprights and a double casing of planks, the intervals between these being filled in with earth; it was also blinded overhead with earth one and a-half to three feet deep.†† While this gallery was being constructed, the fire of the place was kept under, as far as possible, by musketry and guns from the lodgments, and other works of the besiegers. "In the universal affair of the siege there is nothing more dangerous

* Turner. "Pallas Armata;" he derives the word from the Italian "zappa," a mattock.

† "Pallas Armata."

‡ Ludlow's "Memoirs," p. 81.

§ "Art of Fortification," p. 36.

‖ Note that wet ditches are called "moats," and dry ditches "graffes," in almost all contemporary literature.

¶ Hexham.

** Fascines and faggots are usually called "kids" in contemporary accounts.

†† Hexham, Turner, Venn, etc.

than this enterprise," says Venn.* By working at night, under the protection and shelter of blinds and mantlets of fascines called "candlesticks,"† the danger might be minimized.

The gallery across the ditch having been brought up to the face of the escarp wall, the miner was attached, and a mine gallery driven for the purpose of lodging a mine, or mines, for the demolition of the wall and bastion. Mines were preferred to breaching by guns, not only as being more effective against works of a provisional character, which were largely composed of earth, but as likely to be more successful in the formation of breaches even in works with masonry revetments; for the old masonry walls were exceedingly thick, and strongly consolidated, and the breaching of them, by artillery fire, difficult and expensive.‡ The mine itself was driven in the following manner:—A horizontal shaft (see *Fig.* 6, *Plate* I.), was driven through the escarp wall from the extremity of the gallery across the ditch. This shaft, or gallery (*bc*), was made four feet high and three feet broad. One or two turnings, as at (*c*) and (*d*), were made in advancing, with the intention of "deluding" the besieged, and finally, on reaching the intended position of the mine, a chamber for the powder (usually in barrels), some four or five feet high, three or four feet broad, and of varying length according to the requirements of the charge, was excavated. The earth removed in this operation was taken to the head of the gallery and thrown into the ditch. The charge having been placed in position, the entrance (*e*) to the chamber was stopped with "highe plancks" and spars, a small hole being left for the attachment of the train, and the matter was completed by tamping from (*e*) to (*b*) with "good earth." Other writers similarly describe the operation, but vary in the dimensions given to the gallery and chamber. Turner would appear to recommend a gallery seven feet high, and only four feet broad, remarking that "this last, and indeed, perhaps, no mine is for a fat, corpulent man."§

Where guns were employed for breaching, the principle seems to have been to employ the heavier "cannon" and "culverins" at ranges as close as possible. The former pieces shattered and shook the wall, while the culverins "cut out" and brought away portions of

* "Military Architecture," p. 49.

† "Military Architecture," p. 49. "Faggots which they set upon cleft wood, commonly called candlesticks," is Venn's description of these mantlets, or blinds.

‡ Turner alludes to this fact in "Pallas Armata.

§ "Pallas Armata," p. 319.

the disjointed masses. For a breach to be made in 12 hours firing, Turner proposes eight cannon and six culverins, while four demi-culverins, meanwhile, destroyed the parapets, and silenced the armament of the flanks.* The cannons were usually employed frontally, while the culverins took the wall obliquely; the demi-cannons, enfilade fire not having yet come into use, played frontally against the flanks. Venn† has a long discourse on the attack, "by way of a dialogue" between a General and a Captain, from which a few extracts may be here given. He would, in large places, attack a curtain in preference to a bastion, as in such places the bastions were so far apart that danger, from the flanks, was minimized, and the curtain once penetrated, retrenchments were not so likely to be met with as if entry had been made into a bastion. A small place, or a castle, he would attack by way of the bastions. The breaching battery, he thinks, should comprise only cannon or demi-cannon, "good store" of the latter being preferred to a less number of the former, which were less handy. He recommends a battery, or a series of batteries, similar to that which has been described, and similarly disposed, which should consist, in all, of 18 pieces. From these 18 pieces he calculates, in 10 hours, to fire 1,500 rounds, allowing, occasionally, time for each piece to cool. Incidentally, he mentions that a barrel of powder contained 165 pounds, as 150 barrels, or 25,000 pounds of powder, would be required for such a breaching battery. The batteries were to be made as close to the place as was possible, even on the covered-way; "'tis true this cannot be done without danger, and the loss of men, but he that is fearful must stay at home, and not come into the wars, where there is neither place nor time which doth free or exempt him from danger."

The breaches having been made practicable, the final stage of the attack—the storm or assault—took place. The methods employed in carrying out this culminating operation may be best exemplified by the citation of an instance actually occurring during the course of the War. The storm of Bristol, in September, 1645, by the troops under the command of Sir Thomas Fairfax, affords an admirable instance of a determined and well-arranged affair, which was conducted to a successful issue after a strong resistance on the part of the Cavaliers. It has been minutely detailed by Joshua Sprigg, Fairfax's chaplain, in his work called "Anglia Rediviva,"‡ and the

* "Pallas Armata," p. 318.

† The "Compleat Gunner," p. 82-86, in "Military and Maritime Discipline."

‡ Or "England's Recovery." 1647.

clear and dramatic account given by him may be easily followed with the aid of the plan of the fortifications of the city, which is herewith given in *Plate* V.

Storm of Bristol, September, 1645.

Monday, Sept. 1. * * * * * * Orders were given for all the Colonels to view the line and works; and for our souldiers to make faggots and all fitting preparations for a storm.

Tuesday, Sept. 2.—A Councel of War being called and all the Colonels present; after a long debate, whether to storm Bristol or no, it was put to the question, and resolved in the affirmative, and for the manner of the storm it was referred to a committee of the Colonels of the Army, to present in writing to the General the next morning, to be debated at a general Counsel of War. Accordingly, Wednesday, September 3, the manner of the storm was presented in writing to the General, which was to be after this manner. Colonel Welden, with his Brigade, consisting of the four regiments that were at Taunton (viz., his own, Colonel Inglesbie's, Colonel Fortescue's, and Colonel Herbert's regiments, whose parts were to make good Somersetshire side), was ordered to storm in three places, viz., 200 men in the middle, 200 on each side, as forlorn hopes to begin the storm; 20 ladders to each place, two men to carry each ladder, and to have 5s. apiece; two sergeants that attended the service of the ladder to have 20s. a man; each musquetire that followed the ladder, to carry a fagot, a sergeant to command them, and to have the same reward: 12 files of men with fire-arms and pikes to follow the ladders to each place where the storm was to be: those to be commanded each by a Captain and a Lieutenant; the Lieutenant to go before with five files, the Captain to second him with the other seven files; the 200 men that were appointed to second the storm to furnish, each party of them, twenty pioneers, who were to march in their rear; the 200 men, each to be commanded by a Field Officer, and the pioneers each by a sergeant: (those pioneers were to throw down the line, and make way for the horse); the party that was to make good the line to possesse the guns, and turn them; a gentleman of the ordnance, gunners and mattrosses, to enter with the parties; the drawbridge to be let down; two regiments and a-half to storm in after the foot, if way were made. Much after this manner was the General's Brigade under Colonel Montague's command, consisting of the General's, Col. Montague's, Col. Pickering's, and Sir Hardresse Waller's regiments, to storm on both sides of Lawford's gate, both to the river Avon, and the lesser river Froom; the bridge over Froom to be made good against horse with pikes, or to break it down.

Col. Rainsborough's brigade, consisting of his own, Major-General Skippon's, Col. Hammond's, Col. Birche's, and Lieut.-Colonel Pride's regiments, to storm on this side the river Froom, beginning on the right hand of the sally-port up to Pryor's-hill Fort, and to storm the Fort itself, as the main business: 200 of this brigade to go up in boats with the seamen to storm Waterfort (if it were to be attempted). One regiment of horse, and a regiment of foot, to be moving up and down in the closes before the royal fort, and to ply hard upon it, to alarm it, with a Field Officer to command them. The regiment of dragoons, with two regiments of horse, to carry ladders with them, and to attempt the line and works by Clifton and Washington's breach.

The manner of the storm being thus agreed on (though its probable some more certain information might change the attempts from one place to another), the souldiers were drawn out to try their inclination, in whom more courage, joy, and resolution, could not appear in men. The General to make good his promise to reward them for the service of Bridgewater, ordered them immediately to receive 6s. a man, which by the care of the Commissioners of Parliament was forthwith paid unto them, and which put a great obligation upon the souldiers.

* * * * * * * * *

The report concerning the storm being made unto the Counsell of War, and fully agreed unto: the canon baskets were ordered to be filled, seamen and boats sent for.

Thursday, Sept. 4.—The previous wet weather began to lift; with the result of "the great reviving of the drooping souldier." On this day the heavy ordnance played from the "new battery" against Prior's Fort. "Summons was also prepared to be sent to Prince Rupert; and being agreed unto was sent in accordingly." Up to the 9th of September negotiations between the garrison and the besiegers proceeded, but with no satisfactory result so far as the wishes of the besiegers were concerned, and by midnight on Tuesday night, the 9th of September, all hopes of obtaining the city by treaty having failed, it was resolved to storm. As Sprigg continues his account: "At 12 of the clock in the night the General went into the field to give orders about the drawing out of our men, and managing the storm for the next morning. * * * * * the whole Army, Horse and Foot, being set in a posture round the City to fall on about two in the morning, September 10, the signall was given to fall on at one instant round the City and Works, which was by setting on fire a great heap of straw and faggots on the top of an hill, and the shooting off four great guns against Pryor's Fort, from the place where the General was to recide all the time of the storm, which being accordingly given, immediately the storm began round the City, and was terrible to the beholders." The storm was generally successful, the line being carried in many places, and especially on that portion which extended from Prior's Hill Fort to the Frome and Avon, in a south-easterly direction. The seamen, at first ordered to "storm by water," were, owing to the failure of the tide, landed, and assisted on the other side of the line. The forts still held out however; at last Prior's Hill was carried, although the ladders provided for its escalade proved often too short, "Captain Lagoe, of Lieut.-Colonel Pride's Regiment, being the first man that laid hold of the Colours." The garrison, commanded by one Major Price, a Welshman, were, for the obstinacy of their defence, almost to a man put to the sword. By the time it was gained day began to break. On the Somersetshire side the works of the defence were too high for the ladders, and the storm on this side was not crowned with any success. About four hours after the taking of Prior's Hill Fort, Prince Rupert opened negotiations, and the city being on fire in more than one place, Fairfax, in his desire to save the conflagration that was probable, consented to reopen negotiations if the Royalists extinguished the fires. This being done by seven p.m., articles were concluded, and the city surrendered on the next day.

Such, from first to last, was the procedure of the attack in the course of the Civil War; of every incident of it examples occur in the accounts of the sieges of the time. In the Appendix are given what may be called the journals of the sieges of Basinghouse in 1644–5, and of Colchester in 1648. These, with the respective plans of those places, may be instructively perused by such as take an interest in the events of the War. The journal of Basinghouse gives us an account of the gallant resistance made by a small garrison against a large attacking force, and that of Colchester illustrates the progress of a determined, and ultimately successful, attack. They are both good instances, and are reproduced from originals, which are extremely scarce.

One very curious survival of ancient methods of attack remains to be briefly noticed. The moveable towers, and similar machines, to enable the besieger to approach under cover, and deliver an assault under favourable conditions, which had been in general use in the middle, and earlier, ages, appear to have been revived in the practice of the Civil War. They were all included, by those who lived and described them at the time, under the general title "sow," and although it has been supposed that the Rev. William Chillingworth, the great controversialist, was the re-introducer of these engines at the siege of Gloucester in 1643, one Felton, a brother of the man who, earlier in the century, assassinated the Duke of Buckingham, advances his claim to a prior invention of a machine similar to that used by Chillingworth before Gloucester. Felton's account* goes to prove that his engine had been favourably reported on so early as October, 1642, by Major-General Skippon, whose certificate is given in Felton's pamphlet. The machine consisted of a shot-proof wooden tower, built in tiers, and filled with musketeers, 10 in each tier, who were to discharge arrows. The committee for the fortification of London gave the "engine" a practical trial in February, 1643, and highly approved of it. Whether or not this machine was the original, it is recorded that 20 such or similar machines were made at Oxford and sent to the siege of Gloucester,† where some of them were certainly used, as Dorney, the town clerk of that city, in his account of the siege, mentions such "sows," and ascribes them to Chillingworth.‡ Similar machines were used at other places also; at Corfe Castle, in 1643, both a "boar" and a "sow" are mentioned, and it is stated they were made of boards "lined," or faced, with wool, "to dead the shot."§ This particular pair of engines seem, however, to have been of no great height, and to have only protected one tier of men, whose legs, being visible below the machine in its advance, showed the enemy where the vulnerable points of the animal were to be found, a fact of which advantage was promptly taken, with the result of discomfitting the attack. The higher machines, used at Gloucester, were moreover provided with a moveable bridge, which was intended for the passage of the ditch. An

* "Engines invented to save much Blood and Moneyes." "Thomason Collection," E 44. 15.

† "Thomason Collection," E 44. 15.

‡ "Thomason Collection," E 67. 31. For an account of Chillingworth, see Dallaway's "Arundel," at the defence of which place this divine acted as Chief Engineer.

§ Mercurius Rusticus, quoted in Banke's "Story of Corfe Castle."

account of a machine similar to this last, has come down to us in the pages of Vicars' "Parliamentary Chronicle." Vicars says* in describing one that the Royalists intended to use against Canon Frome, but which was captured by the enemy, "The engine was such a one as the like hath not been known since these wars; the Roysters call it a sow; it was carried upon great wheeles, and to be drawn by Oxen; it was made with rooms, or lofts, one over another, musquet-proof, and very strong, out of which were holes to play and shoot out. It was so high that it was above all the works of Canon Frome, so that they could discharge over the works, besides which a door opened to bring them into the works, out of which a bridge went for their entrance." It is probable that this very engine, or machine, was one of those originally constructed for the siege of Gloucester; for it was brought by the Royalists from Hereford, to which Royalist garrison it no doubt found its way after the siege of Gloucester was raised on the advance of Essex.

The Defence.

In the course of the War many of the inland towns of the kingdom, the possession of which was of strategical and local importance to one or both of the contending parties, were fortified and occupied by garrisons. Where old walled defences existed, these were not only themselves strengthened, but additional out, advanced, and detached, works were thrown up in connection with them, with the object, either of giving a greater development to the defence, or of providing a better flanking defence for the old enceinte. Where there were no walls, provisional enceintes had to be provided in the place of the walls, and the whole of the works of the defence arranged in accordance with the requirements of modern science, subject to the time and means available in each individual case.

The manner in which places already provided with walled defences could be placed in a defensible condition, more suited to modern requirements, is thus detailed by Venn.† "An ancient Rampar, if it be strong and surrounded with a wall and Towers, must not be demolished, therefore you must inclose it with a new fortification which must be Regular, if possible, or as near a Regular as might be. Betwixt the New Fortification and the old Ditch there must be left a large Pomœrium fit for military uses." He goes on to say,

* Vicars' "Burning Bush not consumed," p. 318.
† "Military Architecture," p 40.

"many French and Dutch cities were fortified with Ravelins, Half-moons, Hornworks, and other sort of works, which sort of building, since 'tis to supply the place of Bulworks, ought to be stronger than usual. They are likewise frequently fortified with a Faus-bray, and the Brestwork of the Covert way; and sometimes with a Ditch about this Out-brestwork, and with Stakados." The practical result of these arrangements was to provide a new and continuous enceinte in advance of the older one, but this plan seems in England to have been but partially carried out in only one or two cases, as at Portsmouth and Oxford—see the plans of those places. The commoner plan, during the Civil War, seems to have been, in the cases where old walls existed, to occupy important points beyond the enceinte with advanced and detached works, which, in some cases, were connected by a continuous line, and in others, were merely a series of disconnected works, and to provide outworks for the better flanking of the old walls. Typical examples of these methods may be seen in the accompanying plans. At Reading and Newark we have a new provisional enceinte, supplemented by advanced and detached works which are not connected. At Bristol the detached works are connected by a continuous line of trench, and this also occurred at Plymouth. In the case of London we have what is, to all intents, a new enceinte surrounding the boundary of a city which had overpassed the limits enclosed by its original walled defences. While at Worcester and Colchester may be seen the outworks required to improve the flanking defence of the old walls.* The old walls

* "Flanker" was a term often applied to such works. Only one such work —at the north-east angle of the city wall—is shown in the plan of the siege of Colchester. Carter, the Quartermaster-General and Engineer of the Royalist garrison, mentions that there was only one flanker, called the Old Fort, and that it was in bad repair (p. 114 of his "Relation.") The correspondence between the plan—a Roundhead production—and Carter as regards this point is testimony to the accuracy of both. But the author of the "Life of Fairfax" has the following note at p. 310 of his work. "Carter * * * * states that the walls had only one flanker, and that very bad too, called the Old Fort. He means the *balkon* on the west wall. It is impossible that he could have been ignorant of the existence of the flankers in the east and south walls, (these were small masonry platforms for ordnance, not flankers in Carter's acceptation of the term). He makes this assertion to exaggerate the difficulties of the defence. This man was clearly an unreliable authority (!) Elsewhere (p. 335) he also says "Clarendon himself was so ignorant concerning the whole transaction (the siege), that he actually says that Colchester was not fortified." But Clarendon cannot with justice be charged with ignorance any more than Carter with inaccuracy. The place was invested and hotly assaulted within 18 hours of its occupation (including in these hours a whole night), and there could have been no time to raise deliberate defences. Clarendon means that no fortifications, besides the old walls, existed when the place was assaulted. Mr Markham's cavalier (using the adjective in one sense, but certainly not in

themselves were in most cases strong enough to resist the projectiles of the ordnance brought against them, but when the matter was otherwise they were strengthened by backings of earth, or where this was not feasible, as in the cases of mansions and churches, the towers of which were so frequently used as emplacements for guns, sacks of wool were sometimes hung over the exterior surface to "dead" the shot. Of the detached and advanced works, which occupied important positions beyond the enceintes, the majority appear to have been traced in accordance with the rules of the Dutch school, which have already been detailed. The general principles affecting the occupation of ground seem to have been well appreciated by the engineers of the time, and the distances of the works from the enceintes seem to have been regulated by the effective ranges of the firearms and ordnance in use. Some of the instances which are still to be seen—for a personal inspection of the neighbourhood of many towns has proved that at least the sites in some cases, and in others the remains, more or less perfect, of the actual works, may still be easily traced—show that square bastioned forts were more commonly employed than works designed on larger polygons. The most perfect existing specimen of such a fort that has yet been met with is the outwork called, in the plan of the siege of Newark, the Queen's sconce. This still exists at Newark in a field not far from the road leading south out of the town, and the King's sconce, and several of the besiegers' works on the island between the two branches of the Trent, are to this day easily recognisable on the ground. In other cases, as at Worcester, the sites of works shown on the contemporary plans are unmistakeable. The advanced work at Worcester was called the "Royal Fort," and this term was also applied to important works in other places, *e.g.*, to the pentagonal bastion fort on St. Michael's Hill at Bristol. According to Venn * there were three kinds of "Forts Royal;" the greatest of these was that "whose fichant line (or line of defence) does not exceed a musquet shot;" the medium size had the line of defence less than a musket shot, "but the distance of the Bulworks more;" the least of the forts royal had the distance between the salients of the bastions equal to musket shot. The forts royal of the Civil War,

another) treatment of these two contemporary authorities, when their statements did not happen to fall in with his own misconceptions and inclinations, is apparently but another instance of the prejudiced views, and distorted interpretations, which are only too common in partisan works dealing with the history of the War.

* Venn. "Military Architecture," p. 4.

however, appear usually to have been even smaller, and were, in fact, only important field works.* One of the strongest detached works that appears to have been built during the war was that which, on the plan of the defences of Reading, is called "Harrison's Barne." It is more than once mentioned in contemporary literature as having been an especially strong work, and was dignified with the title of "the invincible fort."†

As examples of the outworks constructed round strong mansions and detached castles, the plans of Basinghouse and Donnington Castle may be consulted. The remains of these works are still to be seen *in situ*, and have been compared with the plans within the last few years. The plans are substantially accurate, though in the case of the works round Donnington Castle, there is room for doubt as to the actual trace, as shown on the plan of the eighteenth century.

To illustrate the manner in which the details of such works were carried out, the following description of the forts and continuous line of entrenchment surrounding Bristol in 1643, drawn up by a contemporary eye-witness, and believed to be by the hand of De Gomme himself, may be cited. After deciding the preliminary operations of reconnaissance and investment, De Gomme proceeds to say‡:—"The City of Bristol stands in a hole; and upon the north side,§ towards Durdham Down, lie three eminent knolls or rock hills, now crowned with so many forts. Next the river on the southern skirt of Brandon Hill is the water fort, and on the nape of the hill more northward is Brandon Fort itself, some 18 foot square‖ and as many high; its graff or mote but shallow and narrow, by reason of the rockiness of the ground. This is the highest of the fort hills. From whence the line or curtain runs eastward down the hill, at the bottom of which stands the barn and spur¶ where we

* A plan of the Royal Fort at Bristol is given on the margin of Millard's map (1672), and shows us that the work was built on an irregular pentagon. This plan has been reproduced in Barret's "History of Bristol," and less correctly, also in Seyer's "Memoirs of Bristol." The original fort was constructed during the Roundhead occupation of Bristol, being then known as the Windmill Hill Fort; it was enlarged and called the Royal Fort during the Cavalier occupation. "By judgment of good soldiers" it was considered "the most absolute fortification in Europe." Merc. Civ. E 302. 4.

† "Thomason Collection," E 42. 7.

‡ "Memoirs of Prince Rupert and the Cavaliers." Eliot Warburton, vol. II., pp. 236, *et seq.*

§ More accurately north-west.

‖ Something wrong here. Probably 18 yards or paces is intended.

¶ A "barn" is a casemated and loopholed building. This particular "barn" is afterwards said to be of stone. A spur is a redan or ravelin.

first entered which is since called Washington's breach. Thence trends the line still eastward up St. Michael's Hill, on the knoll of which stands the Windmill Fort, though not fully so lofty as Brandon Hill, yet within four hundred and twenty passes* by a line of it. At the bottom of this hill and upon the highway side stands Alderman Jones' house with a battery across the way, which the line crooks a little northward to fetch in. Up the hill again, more easterly, and within musket shot, there is another redoubt some eighteen foot square, against which Colonel Bellasis' battery played. Within less than musket shot of this is Prior's Hill Fort, four square, each side twenty-four of my paces. And hence trends the line southerly towards the town where, at the bottom of the hill in the meadow called Stokes' Croft upon Gloucester highway, and within more than half musket shot of Prior's Fort there is a great spur work † in the line, and a strong high traverse or work watching and shutting up the highway with a strong post of timber bars on the east side of it. And there lie the main works we had to attack on our side, having in all five cavaliers and batteries, in the middle of every two of which lie also little ravelins or tenailles, thrusting out sharp angles to flanker and scour along the curtain. I measured no further because we had to deal no further. These forts be all palisaded, but have no fauxbrayes or fore-defences, nor on some sides not so much as a barn, corridor, or footbank. Their dry rock graffs lie also narrow and shallow. These forts command all the valley towards Durdham Down northwards, and back again over the whole city southwards. Through all these forts from river to river runs a continued line or curtain of mean strength, and not comparable to those of Oxford. Its height commonly about a yard and a half, or six feet where the highest; the thickness on the top above a yard usually. The graff or ditch commonly two yards broad, but somewhere a foot or two more. The depth scarce considerable, as being hardly five foot usually, and in many rocky places not so deep. The ditches about the redoubts ordinarily about eight or nine feet deep and so much over.

"And thus was the city fortified on our north side, but the south

* This distance may be measured on the plan which, as regards the position of the works is fairly accurate. Without a reference to the original M.S., it is impossible to say whether the dimensions given have been correctly transcribed by Warburton.

† Afterwards called "a double ravelin or spur."

side, where Prince Maurice fell on, though it has not such forts, yet is the line there something stronger besides that it is fenced with the river. The whole circumvallation is full five miles. The ground in most parts so rocky that it being at a Council of War debated whether to fall on by approaches or by storm, the former way, though the safer, was rejected, for the stoniness admits nor mines nor sapping.

"Within the city is a large old castle, but weak still notwithstanding the enimies had something repaired and fortified it. It is wet but in some places, nor hath it fauxbrayes on all sides, and towards the south next the river a redoubt. The Governor of Bristol was Colonel Nathaniel Fiennes, son to my Lord Say and Seale, who, to defend all these works, had some ninety-four iron pieces, sakers, and others, besides two small brass two-pounders, and two four-pounders. In the castle was a long brass murderer, and diverse small iron hammered pieces before the castle and in the forts and streets, mounted upon little carriages, about a yard and three quarters long, of the bore of double rabbinetts or double hacques. They were made by a country smith, and shot a pound or more of musket bullets, or one pound iron ball. The strength to man all these works was three hundred horse and fifteen hundred foot, besides townsmen."

(After describing the assault, which was successful between Brandon Hill and the Windmill Hill Fort, the narrator goes on to say):—

"And thus was the enemy's line won presently by fine force and valour of our men. Nor can the enemy's beating from it be altogether excused, as Governor Fiennes fain would for that their works were not quite perfected, the ditch not being made withoutside nor the footbank withinside the work, and there being but a weak guard in that place. But plainly the line was as high and the ditch as broad and deep there for aught we observed as ordinarily in other parts, though to confess the truth the line was but weak everywhere. However, the place (where they entered) was stronger by a great spur-work, and the stone barn filled with defendants just on the right hand where we entered † * * *

* * * * * * * * *

A heap of them (the Royalists) now newly gotten over the line

† The place where the line was penetrated was ever afterwards called "Washington's Breach." The hero of this exploit, Sir Henry Washington, was first cousin twice removed to George Washington, the hero of American Independence. Markham's "Life of Fairfax," p. 245, note.

and being there charged by the enemy's horse before they could rank themselves into order, made up altogether with much good speed into a lane towards the town, the enemy retreating still before them. And here all unknown to ours the enemy had a strong work, and they in it suspecting our men's running haste to be the courage of such as persued the victory and were resolved to carry all before them, with as much haste ran out of it. Essex work they call this, which lies loftily in the very entrance into the suburbs and overlooks them and the quay."*

In 1644, after the capture and occupation of the city by the Royalists, the changes made in the defences may be gathered from the following extract, taken from the declaration† published by Prince Rupert, after he had surrendered the place to Fairfax, in September, 1645. The line defended by the Royalists was four miles in extent, and with the exception of the forts themselves, appears to have been weak and certainly too extended for the troops available for its defence. The report of the Engineers is as follows :—

"The line generally was three foot thicke. The height of it five foot where it was highest. The graffe commonly six foot broad and where it was widest but seven.

"The depth in most parts foure foot and five where deepest.

"Between Pryor's Hill Fort, Stokes Croft Gate, and beyond the little river towards Lafford's Gate, in which place the enemy entered, not five foot high. The graffe five foot broad, and all that part of the line much decayed.

"The ditch of the great fort, on the right hand the gate before the face of the Bulwork, was not foure foot deep and eighteen foot broad, so that horses did go up and down into it.

"The highest worke of the Fort was not twelve foot high and the curten but ten.

"Within one hundred foot of the Fort there was a deepe hollow way where the enemy might lodge what numbers hee pleased, and might be in the graffe the first night, and in that part the Fort was minable.

* Such were the works, and such the operations which resulted in the capture of Bristol by the Royalists in 1643. Fiennes, the Governor of Bristol, was for this rendry of the city tried and condemned to death, but was reprieved. See trial among the "State Trials."

† A declaration of His Highnesse Prince Rupert, etc., published as per M.S., date 11th November, 1645. "Thomason Collection," E 308. 32., also given by Warburton, III. 164., *et seq.*

"Brandon Hill Fort was about twelve foot above the levell of the great Fort, and that being not able to make any long resistance, the enemy gaining it would command the other.

"The Hedges and Ditches without the Line were neither cut nor levelled, so that they lodged their men securely near our works at their first approach.

"We doe here under our hands attest the particulars above-written to be true.

"B. DE GOMME, Engineer-General,
"JOHN MANSFIELD, Engineer."

We have more detail regarding the works about Bristol than of, perhaps, any other fortified town or city of the time of the War; the accounts of its two famous sieges in 1643 and 1645, written by contemporaries, are also especially full and dramatic, and as examples of the sieges of the time, no better could be selected for the consideration of the military student. But to describe the incidents and to analyse the accounts of the sieges, would take greater space than can here be spared, and we can only follow the example of Prince Rupert as he marched out in 1645, who was observed to "looke backe with much earnestnesse" to the "Royall Fort" as "unwilling to leave it."* No doubt the Prince, as he rode across Durdham Down escorted by Fairfax, who gave him "the right hand all the way," himself dressed in "scarlet and silver," and riding "a very gallant black Barbary horse," with his own lifeguard of Firelocks, "all in red coats before him," and as he looked back on the Royal Fort, "which certainly is one of the bravest citadels in England, in it four and twenty pieces mounted on five bastions," and which, by the judgment of good soldiers, "is the most absolute fortification in Europe," may have thought that under happier circumstances—for the game was up and the last cards were being played by the Cavaliers—he might have made a prolonged and gallant defence of the outlying forts even had he been obliged to render the city itself.† Much blamed for the premature surrender of Bristol, indeed losing his commission on account of it, he was finally, at Newark, on the 18th October, acquitted of blame by the important Council of War or Court Martial convened by the King

* "Mercurius Civicus," No. 121. "Thomason Collection," E 302. 4.

† An exact relation of Prince Rupert, his marching out of Bristol, etc., "Thomason Collection," E 302. 3. "Mercurius Civicus," No. 121., E 302. 4.

to enquire into the circumstances of the surrender,* notwithstanding the openly expressed hope of some of the Roundhead newspapers that "the sentence of death in the strictest way of war" might be passed upon him.†

The important works raised for the defence of Oxford and London, deserve, at least, a passing mention. They are, in each case, an example of the interior lines which were constructed for the protection of what was, to all intents, a "naked" or open city.

The plan of the works at Oxford ‡ shows the influence of the Dutch school in a greater degree than, perhaps, any other example of fortification of the War. The works consisted of a first line of large bastions, enveloped by a continuous counterguard, beyond which again was a ditch and a covered-way. The ditches, except on the north side, were wet, and could be filled by the employment of water manœuvres. To whom is to be assigned the whole of the design is somewhat doubtful. It is stated by Wood, under date 19th April, 1643, that "the works and fortifications also did now go on apace, and those in St. Clement's Parish, on the east side of Oxford, were about this time begun, which, with other fortifications about the city, were mostly contrived by one Richard Rallingson, Bachelor of Arts of Queen's College, who had also drawn a mathematical scheme or plot of the garrison. His endeavours in this nature gave so great satisfaction to the King, that he forthwith sent letters in his behalf to the University to confer the Degree of Master of Arts upon him, which letters being read in Convocation, 17th October, he was admitted Master of Arts.§ In September and October of the same year, there appear to have been "thoughts" of "new fortifying" the city, the works that had been previously made "giving not content,"|| and, on the 18th January, 1644, it appears to have been arranged that work by scholars and servants on these works should be compounded for at the rate of £40 weekly,

* Constitution of the Court: Earl of Lindsay, Lord Great Chamberlain; Earl of Cork; Lord Astley, Field-Marshall-General of the Army; John Bellasis, Captain-General of Horse Guards; Charles Gerrard, Lieut.-General of the Horse; Sir Richard Willis, Governor of Newark; John Ashburnham, Treasurer at War. Warburton, III.

† Moderate Intelligencer, No. 29. "Thomason Collection," E 302. 2.

‡ Taken from Latin Edition of the History by Wood.

§ "History and Antiquities of the University," Anthony à Wood (Edition Gutch), II., p. 462.

|| "History and Antiquities of the University." Wood. (Edition Gutch), vol. II., p. 467.

for a period of 20 weeks from the 22nd January.* An order had previously (in June, 1643) been passed, that all scholars and residents in the colleges should give labour one day in every week, or, in default, pay a shilling for the construction of the works.† Again, in May, 1646 "many additions" had been made to the fortifications during the past year, and the description of the works, given by Wood, occurs at this place, and probably refers to the whole of the works carried out up to this date.‡ In both the Latin and English editions, Rallingson is mentioned as the engineer, but, in the Latin edition, it is further stated that one Beckmann constructed works about the city. It has been supposed, therefore, that the original enciente is to be ascribed to Rallingson, but the additional envelope or counterguards to Beckmann.§

Wood's account of the fortifications is as follows :—" And though it was always accounted justly a place of considerable strength, yet now (May 3rd, 1646 ?) it was made incomparably more strong than ever, it being the King's headquarters and garrison, and his chief place of residence and retreat. The situation, in reference to the ground it stood on, rendered it very apt for defence, being placed between the river Isis on the west, and Cheswell on the east, both meeting in the south side. Which rivers, especially the first, spreading themselves into several branches, which ran under and through some parts of the city, were so ordered by locks and sluices placed upon them, that the city could be surrounded with waters (except the north part) when the defendants pleased, and thereby make the place absolutely unapproachable. As for the said north part it was indifferently high in relation to the other ground, having so many strong bulworks, so regularly flanking one another thereon, that nothing could be more exactly done. Round about the line, both upon the bulworks and the curtain, was strongly set with storm poles. || Upon the outside of the ditch or trench round the said line it was strongly pallisadoed, and without that again were digged

* "History of Antiquities of the University." Wood. (Edition Gutch), vol. II., p. 467.

† "History and Antiquities of the University." Wood. (Edition Gutch), vol. II., p. 463.

‡ "History and Antiquities of the University." Wood. (Edition Gutch), vol. II., 479.

§ See the matter discussed in "Proceedings of the Archæological Institute," Oxford, 1850, by Captain Rigaud, 60th Rifles. Captain Rigaud states that the Latin translation of Wood's work is not by himself, but by one Richard Peers. The Latin edition is dated 1674.

|| Probably fraises are intended.

several pits in the ground that a single Footman could not without difficulty approach the trench. Within the city there was 5,000 good foot, most of them of the King's old infantry, which had served him from the beginning of the wars, and withall they were well stored with a plentiful magazine of victuals, ammunition, and provisions for war. In a word, whatever art or industry could do to make a place impregnable, was very liberally bestowed here."*

A very minute and interesting account of the fortification of London is given by one William Lithgow, who made a perambulation of the line of defence in 1643, when the works were being constructed. Extracts from his pamphlet, which was printed in the same year, are given in the Appendix, and are full of information regarding the details of such works as constructed at this time.

Neither Oxford nor London appears to have been provided with detached works in advance of the main line of enciente, as was the case at Reading. The plan of this last place, here reproduced from an original in the British Museum, has never yet been published, and, as regards the position of the main advanced work called Harrison's Barn—the "invincible fort"—is of singular interest, as all local histories have hitherto assumed that position to be, not on the south, but on the west of the town; the remains of the Castle Hill Fort having been supposed to be those of the great fort at Harrison's Barn.†

To strengthen the works of besiegers as well as of defenders, obstacles were usually freely employed. Palisades, fraises, military pits, and "Calthorps," or crows feet, seem to have been most generally applied, and indications of their position may be seen in the plans of Reading and Newark, and in the descriptions of the fortifications of Oxford, London, and other places. Chevaux de frise—"in Dutch a frize Ruyter" says Hexham ‡—were also commonly used, and are usually, in the contemporary accounts, distinguished in English as "turnpikes."§ The English "turnpike" was, however, in some cases, a regular barricade made of timber, and was what Ward || calls a "Bome or Baricado." This obstacle was used mainly at points liable to the incursions of cavalry, the procedure styled "beating up of quarters" being, during the War,

* "History of Antiquities of the University." (Gutch), II., 479.

† See Coate's "History of the Town" and others.

‡ Art of Fortification," p. 31.

§ "Animadversions of War," p. 369, and constantly in contemporary literature.

|| "Animadversions of War," p. 371.

very much in fashion. Palisades seem to have been invariably armed with spikes at the heads, arranged transversally as well as vertically; they are mentioned by all writers, and were usually driven in three rows, and so as to be breast high.* The name of palisades seems also to have been given to fraises, though these latter are also called "storm poles."† Curiously enough abatis seems to have been not in favour during the War, at least no mention of it has yet been met with in the technical works, or in the literature of the War, although the occupation and defence of woods was not uncommon. The "Calthorp" corresponded to the modern crow's foot, and is thus described by Ward:‡—"The Calthorp is an Instrument very offensive to the Enemies Horse, and by the use of them a few soldiers may make an able resistance either in the streetes of a Towne, or upon any passage, or in a Pitche Battell. * * * They are framed in this wise; first they take a tough piece of Sallow§ and making it round about the bignesse of an Apple, there is Iron pikes driven thorow, which points every way, so that which way soever it falls a pike will bee upwards to runne into the feet." He also used the same name to another device which consisted of "a piece of Bord as broad as a Trencher which is driven full of nayles and lyned (backed) with another thin Bord to keep the nayles from slipping backe." Such boards were to be laid down in a passage at night time, and might also, instead of being in small sections "as a trencher," be made of continuous lengths, to close the roadway in a street.||

The general operations and stages of the defence of works, such as those which have been now described, adapted themselves to those of the attack. They may be expressed in the words of Venn:¶ "The first beginning is to keep the enemy from the town as far off and as long as you can. Therefore whatsoever without the works can put a stop to the Enemy the Besiegers must possess and defend as long as they can. They must use all their endeavour to hinder the approaches of the Enemy; therefore let them sally frequently but warily least they fall into snares to the irreparable loss of the

* Hexham. "Art of Fortification," p. 31.

† Ward. "Animadversions of War," p. 370, and see Wood's account of the Oxford "storm poles" (*ante*).

‡ "Animadversions of War," p. 370.

§ Sallow—Willow. Anglo Saxon, "Sealg" the stem of a willow tree (Skeat's "Etym. Dict.")

|| "Animadversions of War," *ut supra*.

¶ "Military Architecture," pp. 50, 51.

Town, and rout and kill the Pioneers and Soldiers ; let them throw down the lines that are finished, and if they cannot carry away their guns they must spike them up by driving Nails in their Touch-holes. Those outward works which they can keep no longer must be retrenched, but if they are utterly like to be lost they must be blown up together with those that possess them. The sapping of the out brickwork must be intercepted by a counter and transverse sappe. The filling of the Ditch and the building of the gallery must be hindered at a distance by the continuall firing of musquets, great guns, hand grenadoes, and other fireworks ; nor is there any other way if the Ditch be full of water. But if the ditch be dry, then they must fall upon the builders of the gallery with handy stroaks, as well as with all that which I declared above. And the gallery itself must either be destroyed by fire, or blown up with a mine. But if notwithstanding all this, the force of the Enemy prevailing, the gallery is brought over to the Bulwork and the Bulwork itself be undermined, against this plague no remedy remains but to find out the place of the mine. To do this they use several practices. Some by the motion of Pease leaping on a Drum-head well braced do conjecture at the place of their digging, others boaring a very long Augur into the Ground suspected and applying their ear to it think to hear the stroakes of their digging ; others use other ways to discover it. The most certain way is by counter-mining to search the foundations of the Bulwork. The mine being found the powder must be carried out ; but if the streightness of time will not permint it must be wetted, and a passage opened for the fire.

"The Bulworks being blown up, if the Besieged have no inward works remaining, the last refuge is, that since they can no longer resist the Enemy with wall and Rampar that they stop his passage with arms and hands as he is breaking in at the breach. Which since they are rather the parts of Captains and Souldiers than the Engineers, I leave the rest to them and put an end to this treatise."

And so also may this account of the attack and defence, the principal of those duties required of a military engineer in the seventeenth century, be brought to a conclusion. As examples of the procedure of the time, attention is again invited to the journals of the sieges of Colchester and Basing House, given in the Appendix, which are full of dramatic details, illustrating the methods and incidents of siege warfare as conducted at this time.

Field Engineering: Pioneer Duties.

Although the main duties of the engineer, coming under this head, have already been considered under the Attack and Defence, those which are connected with the movements of an army in the field remain to be noticed, and may be grouped under the general sub-head of "Pioneer Duties."

The principal duties of the corps of pioneers attached to the train of Artillery seem to have been the facilitating of the transport of the ordnance and its fortification on the field of battle. The corps during the War seems never to have been a large one, constituting, as it usually did in English trains, but a captain's command. It is probable, therefore, that all preparations for the defence of buildings, and provision of shelter for the troops in the field, must have been carried out, as occasion arose, by the various regiments engaged. It is found, however, that the special corps of pioneers was employed on one occasion to facilitate the marshalling of the forces on a field of battle;* this was at Marston Moor on the Parliamentarian side. On Newbury field also traces still exist of the entrenchments which must have been thrown up by the pioneers for the protection of the guns, and at Edgehill also something of the same kind must have been done by the Royalists, whose guns are stated to have been entrenched, and being so, formed a point of support for the retreating infantry towards the close of that doubtful engagement. That pioneers were usually employed to prepare ways for the ordnance is proved by Lord Hopton's account of the operations immediately preceding the action at Alresford (March, 1644), in which it is stated that they were employed by Waller to open up and improve the ways for his artillery, which, by their aid, was rapidly advanced through a wooded country.† In the various operations of a siege, particularly in the closer stages of the attack and in the assault, they, as well as the other trained mechanics attached to the train, must have been constantly employed to demolish obstacles and clear a way for the storming party. At the surprise of Shrewsbury, in February, 1645, a party of carpenters were sent by water to force a passage through palisades, and thus to give entry to a detachment of troops.

With the other mechanical sections of the train they were also, probably, employed in the construction of bridges. A train of

* "Thomason Collection," E 2, 14.

† "Clarendon MSS.," Bodleian Library, 1738(6).

pontoons at this time existed in all regularly constituted armies. We are told that in March, 1644-5, the King had a train of 14 boats made,* and on the 8th May, 1645, Symonds notes that the Royalists marched with " eight boats in carriages."† Pontoons are also mentioned by military writers. Ward, describing various " engines," mentions the use of the " leathern boate," which was so light that a soldier could carry one under his arm.‡ He also gives a woodcut, representing boats on trucks drawn by a single horse, and says: " The Hollanders carry their Skutes and Boats upon carriages, and in them they put their Ammunition and other necessaries, being well covered over with Tilts, or sometimes one Boate covers the other; these Boates they can speedily take off from the carriages, and suddainly make use of them." He also says: " The States of the Netherlands have a kind of an open flat Boat which they terme Punts; these they carry by water to any place they intend to march over, but if * * * they cannot passe by water then they are transported upon carriages and drawn by Horses. * * * They are made like to Horse boates, flat bottomed, the ends open and rising, so that when they are joyned together, the rising ends meeting, it is like an Arch thorow which the water hath passage; foure men may march abreast over them, and they are twenty or thirty foot long a-peece; they are fastened together with iron hookes, and their Masts and Tackling are fixed to the sides of them to strengthen them. The rising ends of these Punts have ledges nayled halfe a foot distance one from the other, to prevent the feet both of men and Horse from sliding; they are stayed with Cables and Anchors from falling down the Streame. These are the surest and best Bridges that ever yet were invented, and very easie to be conveyed either by land or by water; besides many things belonging to the warres may be carryed in them." Other bridges are also mentioned by him made of " small vessels as Hoighs and the like." As shown in his figures these last were placed head and stern in the direction of the flow of the stream. Bridges of casks, on wheels, trestles, and rope bridges, are also mentioned and figured in his work. §

Such, no doubt, were the bridges used during the War, as the organisation of the combatants, in all these matters, followed very closely that of the Netherlands armies. Boat bridges are frequently

* " Slingsby's Diary," p. 142.
† " Symonds' Diary," Camden Society.
‡ " Animadversions of War," p. 379.
§ " Animadversions of War," pp. 376-9

mentioned in the literature of the War; at Selby;* between Battersea and Putney, laid by Essex after the action at Brentford;† at or near Gloucester, by Waller in 1643;‡ over Severn again after the relief of Gloucester by Essex;§ at Chester by Brereton;‖ at the investment of Newcastle by the Scots in 1644;¶ these last are specially noted as having been "flat boates;" at Hull, Newark, and many other places.

Miscellaneous Duties and Usages of War.

Under this, the last, sub-head, and in conclusion of the enquiry, may be collected a few notes relating to miscellaneous matters and usages connected with fortress warfare, and the constitution of the engineer department of the train. As to the relative rank of the engineer, we have it on Markham's authority** that the "trenchmaster," who is also called the "engine master," and "the engineer," ranked above the master gunner and the fire-master, but was, like these officers, under the command of the Master of the Ordnance. Markham incidentally also states that many superior officers, to his knowledge, were excellent engineers, and instances Sir Francis Vere, "Marshal" Sir William Pelham, Sir Richard Hansard, and Sir Thomas Bodley, as being among the number of those who in person performed the duties of an engineer. Markham also states†† that in opening the trenches one of the duties of the captain of pioneers was to dig the first sod. He also tells us that in right of this officer the corps of pioneers were entitled to carry a colour. This custom seems to have existed for some time in the English service, for we find by order of Parliament‡‡ that "the ensign and trumpet" were, in 1644, abolished and struck out of the establishment of the train, then being reorganised.

That working parties received working pay, as was the custom in the Netherlands—a custom introduced by Maurice of Nassau§§—is proved by the statement of Nehemiah Wharton, a subaltern in

* "Slingsby's Diary," p. 105.
† "Ludlow's Memoirs," I., 55.
‡ "Thomason Collection," E 97, 2.
§ "Thomason Collection," E 69, 2.
‖ "Thomason Collection," E 325, 30.
¶ "Thomason Collection," E 44, 10.
** F. Markham. Dec. 3, Epist. 3.
†† F. Markham. Dec. 4, Epist. 3.
‡‡ "Commons Journal," May 6, 1644.
§§ F. Markham. Dec. 4, Epist. 3.

Essex's army, that the men employed on the fortification of Worcester, in September, 1642, received, by proclamation of Essex, a shilling per diem.* Civilian labour, however, and especially in mining, was frequently employed by both parties during the war; instances are many and need not be quoted in detail.

In a war which consisted so largely of sieges, several curious usages connected with the progress of an attack, may here be noted. The summons and reply, and indeed any communication between the besieged and besiegers, was carried by a trumpeter or a drummer; flags of truce then, as now, were white, but "bloody" flags of defiance appear to have been more common in those days than in modern times;† reprisals, less common in the course of the Civil War—though it must be confessed that many barbarous deeds are recorded as having occurred—than in warfare elsewhere at this period, so far as sieges were concerned, were usually carried out by hanging the subjects over the walls in the sight of the enemy.‡ On the surrender of the place, "articles" were drawn up, and specimens of such agreements may be seen in the Appendix. "Quarter," which was "fair," is said, in one case, to have consisted of life with imprisonment, civil usage, and immunity from plunder.§ Pillage of a place taken by storm belonged to the soldiery, and was bestowed on the "valiant soldier" to "encourage" him.‖ In one case it is stated that the arms taken were "free prize" for the officer in command.¶ A garrison that marched out with the "honours of war" usually did so with their arms and ordnance. There were degrees in this ceremony, however, and the actual allowance was rigidly detailed in the articles of surrender. Full honours included "bullet in mouth, colours flying, drums beating, and matches lighted," thus indicating a readiness, if not a resolution, to continue the struggle on the part of the besieged, had not other considerations of policy suggested to them to make a composition. One very curious variation occurred in the case of the surrender of Hawarden Castle, in November, 1644. The garrison here were permitted to march out with half their arms, two-thirds of their colours, half of this allow-

* "Archæologia," Vol xxxv. and "Calendar State Papers Domestic," 1641-3.

† Bloody flags of defiance were hung out at Coventry, August 1642 (E 114-6); Farnham, December, 1643 (E 78-8); Newcastle, 1644 (E 14-9)

‡ The Roundheads hung a man on Lichfield Close walls. Rupert threatened reprisals (E 99, 13).

§ At Arundel defined by Waller, "Thomason Collections," E 81, 21.

‖ "Thomason Collection," E 81, 10; E 47, 2, etc.

¶ At Tickhill Castle, Yorkshire, 1644, E 4, 6.

ance being furled, one horse to the officers, etc.* The bells of a place refusing a summons, and ultimately carried, became the perquisite of the officer at the head of the train. Charles, on the 7th August, 1643, issued instructions to the churchwardens and parishioners of Bristol to redeem their bells, forfeited on the occasion of the capture of the city by the Royalists in 1643.†

Officers surrendering a garrison prematurely were liable to be shot, after due trial by a court-martial. And several instances of the sentences being carried out are given in the literature of the War. Fielding and Fiennes—Cavalier and Roundhead—were both condemned, the former for the rendery of Reading, 1643, and the latter for that of Bristol in the same year; but were both reprieved. In both cases, however, their reputations were never entirely cleared of the stain of dishonour. At Plymouth, in November, 1643, and at Beeston Castle in May, 1644, two Roundhead officers were shot by their own party for surrendering works, while Windebank was similarly treated by the Cavaliers, being shot at Oxford, against the walls of Merton College, for the hasty delivering of Bletchington House to Cromwell in 1645.‡

To thoroughly illustrate the matters considered in this paper, detailed accounts of some of the principal sieges of the War would be required, but such an extension of the subject would carry the present notes beyond the limits assigned to them. Although the notes themselves only presume to be memoranda for the information and guidance of others who may wish to intelligently follow the course of the historical incidents, and investigate the technical methods of the War, it is believed that in them very few points of moment connected with military engineering have escaped, at least, a passing notice. It is also hoped, inasmuch as care has been taken to verify their accurate quotation, that there may be no errors in the accompanying foot-notes and references, which might be consulted as suggestive guides by such as wish to carry to more advanced points, their studies on the military art of the great Civil War.

W. G. R.

* "Thomason Collections," E 32, 13. For ordinary full honours see Articles in Appendix and E 76, 11, E 31, 15, etc.

† "Harl. MSS.," 6842, quoted by Webb in Civil War in Herefordshire, 1, 324. Duncan's history of the Artillery Regiment states that this claim was admitted in 1807, at the taking of Copenhagen by the British, but refused and disallowed at Flushing in 1809 as being an obsolete custom.

‡ "Heath's Chronical," 1676, p. 75.

APPENDIX A.

The preparations for the defence of London against the possible advance of the Cavaliers, as well as an account of the works thrown up with this object, are very minutely detailed in a contemporary account* by William Lithgow, and although the author, a Scotch tailor, born in Lanark, was somewhat unfortunately distinguished by the epithet, "Lying Lithgow," bestowed on him by his fellow-countrymen, there is no reason to suppose that he was so called for any other cause than that he had already published a very verbose and inflated account of the adventures that befel him in Spain and other countries surrounding the Mediterranean, the marvels related in which were generally discredited. As will be seen from the following extracts, his style is in the present pamphlet sufficiently prolix, but the facts stated seem never to have been questioned. After giving a general description of the condition of London, which he entered on the 3rd of May, 1643, having left Prestonpans on April 24th, and travelled by sea, he proceeds to say, "Now for a general view" (of the city's 'insides'). "The citie hath many courts du guard with new barrocaded posts, and they strongly girded with great chaines of yron, and all the opening passages at street ends, for the fields and road wayes are in like manner made defensive and strictly watched. The sides of the river, as at Billingsgate and other places, have also "courts du guard," and they nightly guarded with companies of the train bands, which number being of six old regiments, and they six thousand men, are now doubled with six new regiments, which maketh up twelve thousand in all.

* The present surveigh of London and England's state, containing a typographical description of all the particular forts, redoubts, breastworks, and trenches, newly erected round about the citie on both sides of the river, with the severall fortifications thereof, etc., etc. By William Lithgow, London. Printed by J.O., 1643; reprinted in the "Somers Tracts," vol. IV., 534, *et seq.*, and edited by Sir Walter Scott, 2nd edition, 1810.

Beyond the river, in the borough of Southwark, is the self-same discipline observed, and all under the command of the citie. So is Westminster, the Strand, and all the liberties thereof now taken in under the custodie of London." He then remarks on the "courts du guard," two in number, at Westminster, to protect the Houses of Parliament, and mentions another on "the street-enravelld court before Whitehall Gate," and is astonished to find the "grasse growing deep in the royall courts of the King's house, which indeed was a lamentable sight." While musing over this he "rancountered thereabouts with George Withers, my fellow-poet, and once my fellow-prisoner,* where digesting some discourses (for he is now a captain of a horse troupe) he told me that he had been plundered at Michalmes last by some of the King's forces in Surrey; for there he hath a wife and residence, where being civilized, his poetic mansion met with uncivill fellowes, I would say malignants." Coming to his "maine purpose," he describes "the fairest encompassed city in all Europe, which my pedestriall march in twelve hours time painfully performed." Three days before his departure he made "the toure round about," beginning his "circuit" at the "lower end of Wappinge."

"Here close by the houses and the river Thames, I found a seven-angled fort erected of turffe, sand, watles, and earthen work (as all the rest are composed of the like), having nine port-holes and as many cannons; and near the top round about pallosaded with sharp wooden stakes fixed in the bulwarkes, right out, and a foot distant from another, which are defensive for suddain scalets, and single-ditched below, with a "court du guard" within.

"Advancing thence along the trench dyke (for all the trenches are deep ditched about) which runneth through Wappinge fields to the further end of White-Chappell, a great way without Aldgate, and on the roadway to Essex, I saw a nine-angled fort, only pallosaded and single-ditched, and planted with seven pieces of brazen ordnance, and a "court du guard" composed of timber and thatched with tyle stone, as all the rest are; where towards Myle-end Green I beheld there two pettie forts or redoubts, each of them with three ports, and they cannoned, stand within an intrenched closure, having five "courts du guard," that secure the passage way.

* Probably when Lithgow was imprisoned for striking the Spanish Ambassador in the presence chamber. Being accused by the Spaniard of making a false complaint, he, as he himself expressed it, "contrabanded his fistula with a fist," and was sent to gaol till the ambassador had departed.

"From White-Chappell Fort, north-westward, I trenched along the trenches to Shoarditch Fort, standing mainly quadrangled, single pallosaded, and single ditched, carrying in three corners of the four eight demi-cannons, and a royall "court du guarde" within; and without which and at Kingsland (being the old post-way for Scotland) there stands two earthen rampires with two "courts du guard."

"Thence returned, I followed along the champaine breastworks to Hogston, where I found a quadrat fort, well pallosaded, and planted with five cannons at the two field corners; the strength is double-ditched, and between the two it is strongly barrocaded with wooden stakes, everie stake neare the top being fenced with three iron hookes of a span long.

"Thence I marched through Fineberry fields along the trench (enclosing these moorefields), and came to Mount Mil-hill Fort (for all the forts about are blank and blank in sight of other), where being arryved, I found it standing on the highway near to the Red Bull. This is a large and singular fortification, having a fort above, and within a fort, the lowest consisting of five angles, two whereof towards the fields are each of them thrice ported, having as many great cannon, with a flanking piece from a hid corner; the upper fort standing circular, is furnished with eleven pieces of cannon reall,* which command all the rest; and upon the bosome top of all standeth a windmill; the lower bulwarks are first pallosaded round about and near their tops, and then in the middle flank between the two ditches strongly barrocaded; besides two counterscarps and three redoubts of lesser importance, yet all defensive. This is one of the chief forts about the city and first erected.

"Thence footing along the trench dyke (which is three yards thick, and on the ditch side twice as high) I courted Islington, at the lower end whereof I found a strong and large strength called Waterfield Fort, having, within two outer workes, a circularie mount, stored with nine great pieces of artillerie, and on the point of a countercarp three pieces more; there I saw the longest "court du guard" (being longer than two ordinarie churches) that I have seen as yet. A little further (about ten paire buts) I approached to Islingtôn-hill, where there is erected a most rare and most admirable fortification called Strawes Fort, but now Fort Royall. It hath eight angles and a specious interlarding distance between each of the

* Royal.

cornered bulwarkes. This fort is marvellous perspicuous and prospective both for city and country, commanding all the other inferior fortifications near and about that part of the enclining grounds. The north-east corner bulwark is double altified above the rest of the work, carrying on the two sides thereof six cannon royall; and the two south and west corners are mutually charged on each of them with two half culverins of brasse, and the east promontariat corner adorned with three whole cannon. The altified bulwark is twice pallosaded, and at the root of the work, answerable to the top of the inmost ditch, it is strongly barrocaded; the middle place between the two ditches is enravelled all about with low wooden stakes and long pikes of throwne pointed iron, and without all which works there is a breastwork cast up and made defensive, either for the first assault or for the second invasion.

"Descending thence to Holburne Fields, I accoasted a strength named Pinder of Wakfields Fort, being only quadrangled, pallosaded and single ditched, and enstalled with five great ordnance and a "court du guard." Abandoning the place, and shoaring along the trench a little further to Longfield, I presently rancountred with Northampton Fort, consisting of two divided quadrangled bulwarks, and each of them garnished with four demi-culverins of brasse; the intervening distance fortified; the two former bodies are pallosaded, double ditched, and the middle division whereof barrocaded with stakes a yard high, and each of them hooked with three counter thwarting pikes of iron.

"Whence conducted along with the trenches through S. Geilles' Fields, I arrived at Crabtree Fort in Crabtree Fields, standing in a quadrangle, and loaded with six culverins of brasse placed on the two field corners, defying the malignants, or what assailants may there encroach; the fort is pallosaded above, double ditched below, and barrocaded in the middle division with thick standing stakes, and they counterbanded with thwarting iron pykes and a stately "court du guard" within.

"Leaving this and marching along the circulary line, it grieved me to see so many rich grounds of grasse utterly spoiled with the erection of these works, insomuch that horse and cattell certaynels* will come short of their food there for seven years, and the owners thereof must fall pittyfully short of their yearly profits; for when trouble is then cometh misery.

"Having left the aforesaid fort, I saluted the Banqueting House

* Certainly.

Fortresse, composed of two forts, upon Tayburne way and Maribone Fields. Here I found both the forts answerable to other, the way only dividing them; and they both pallosaded, double ditched, and barrocaded with iron pykes; the one cled* with eight demi-cannon, and the other fenced with foure semi-culverins of iron; both wondrous defensible.

"A little advanced from this Tayburnian passage I insulted upon Sergeants' Fort, composed mainely of foure angles, a "court du guard," five piece of ordonance, and fortified in all things just like to the former.

"Departing thence I shortly encroached upon Head Park Corner Fort, which is a maine great strength, having one fort above and within another, and the third fort closing the roadway standeth breasting the other two. The utmost invelopped fort, overtopping the other two, is garnished with eight cannon reall, and on the inferiour bulwark northward, being a second part of the forts maine body, there bee intrusted there five brazen half-cannons more, and before it towards the fields a breasting countercarp. The third defendant fort standeth enstald with six demi-culverines; amounting to 19 of all. This great fortification is but only pallosaded and single ditched, yet wonderfull strong and of great bounds. All the three having 17 angles. And this is the westmost fortification enclosing the park, the fields, the large mansion, and other enlargements belonging to S. James, his liberty.

"Thence drayning along a devalling trench, through Milk Field towards Tuttle Fields, I rancountred with two half-moon workes, some ten paire buttes distant, both of them pallosaded, barrocaded with irne picks, and each of them planted with three demi-cannon of brasse; both these works stand sighting Chelsay.

"Whence breasting along the breastworkes, I happily imbraced Tuttle Field Fort, my familiar ground of old acquaintance. This fortress is composed of nyne angles, being pallosaded and only double ditched and surcharged at the south and west corners with six pieces of ordnance and a "court du guard." Here is an end of Middlesex labour, from which posternall place I coasted the river syde and crossed over to Lambeth in Surrey.

"In the head of which town westward, and close by the river, I visited the Nine Elms Fort, composed of foure angles, five posts, and five demi-culverins, being slenderly pallosaded and single ditched,

* Clad.

for this fort and Tuttle Fort stand opposite to other, the river only dividing them.

"Whence following my circulary progresse I enhanced my desired view of Fauxhall Fort, which indeed is a delicate large and defensive work, being twice pallosaded, once ditched, and bearing the burthen of 14 culverines. And hence transported amaine with a greedy desire to surveigh S. Georges Field, I found half way hither a singular countercarp and fortified, besides workmanship, with three half culverines. And then I arryved at the Fort Royall in Georges' Field, which indeed of all the works I have as yet made mention of, this is the only rarest and fairest, and contryved and reared after the moderne modell of an impregnant citadale, having foure large bulwarks, every one counterbanding another from flank to flank, and the foure intervening quarters are also interlaced with spacious and defensible midworks; the maine bosome of which, with the incumbent insides of the foure promontories, may easily containe three thousand men, the foure corners being destinated for twenty-foure cannon reall. The exterior works are not as yet accomplished, although fast advancing, but certainly they will be perfyted after the Londonian Forts, as I have newly rehearsed, neither are the trenches done, which are drawn along thence to the top of Southwark, called Nevington Fort. The which is composed of two flanking redoubts divyding nine pieces of ordonance between them, having two "courts du guard," and backed with two countercarps, infringing the roadway passenger, till a condigne tryall of what are you, what carry you, and from whence came you, bee demanded.

"Hence I continued my purpose to the top of Kent-street, and found there only a circulary rampire of smal importance, fenced with a single ditch between two ditches, and enstald with five pieces of ordonance, and so is the other, at the back of Redreiff, but more defensible than the other, yet they are both to be interlarded with redoubts and countercarps in the intrenched grounds. So here at Redrieff Fort, just opposite to Wapine Fort, I finished the pilgrimagious toyle of a wearisome daye's journey, the circuit whereof, on both sides the river, amounted to eighteen Kentish myles.

"From which I may say that London was never truly London till now; for now she sits like a noble lady upon a royall thron, securing all her encroaching pendicles under the wings of a motherly protection; yet these limites were never heretofore granted till the Parliament, for their better safety, confirmed this construction, that (Grand Cayro excepted), I have not seen a larger inveloped compasse within the whole universe. By which computation I apprehend that this circuit comprehends above five hundred thousand dwelling-houses, and in them large three millions of souls; * that methinkes, he were a happy prince that could be but only king of such a city as London now sits intrenched, though he had no more provinces besides.

"And now the maine number of all these circulating fortresses (besides redoubtes, countercarps, and half-moon workes, along the trenches) amount to twenty-four forts in all; and upon them planted and resetled two hundred and twelve pieces of cannon; which is indeed a mighty and tremendous sight; where Vulcan and Bellona mean to make a bloody match, if the esurious assailants should come, in a tragicall, inconsiderable way, to surpryse the virginitie of these new and now almost finished fortifications, which indeed have been very chargeable to the city, and daily will bee more; for all the port-holes are soled and syded with timber; the platformes where the cannons ly are laid with strong oaken planks; all the ordonance are mounted upon new wheeles; besides the pallosading and barrocading of them without with yron workes and other engynes.

"And now sorest, in the daily maintaining of commanders and forces unto them, with ammunition and all things necessarie both for the forts and souldiers. But it is no matter; let Guildhall pay for all; for there lyeth the treasurie and weekly collections of the citie, which amounteth to twelve thousand pound starling a week, besides the countrey about; and moreover the customes, the royall rents, the episcopall revenues, the plundring of malignants, and all lye there; where there are sitting a daily committee appointed by the Parliament and city, who have the disposing of all as they think fitting; notwithstanding they must returne their accounts to both the houses.

"And now in discoursing of these forts, I have been somewhat prolixious, not usual in my former styles, but done of purpose, that the reader may conceive by paper which I have known by occular experience; and so I proceed." * * * * (To other matters).

* This estimate is indeed "large." Assuming 500,000 houses, the souls in them might well be 3,000,000. Several estimates of the population of London in the seventeenth century by contemporaries have come down to us; there are great variations in them, but none are so magnificent as that of Lithgow. Howel ("Londinopolis," 1657), puts the population in his time as one-and-a-half millions. Before the Civil War the civic authorities made it 700,000. Sir W. Petty, in one of his essays on the growth of London, has 84,000 houses and 672,000. Eight in a house is a somewhat large assumption. Probably 500,000 may be accepted as a near approximation to the population of London at the breaking out of the War.

Lithgow, in another part of the same pamphlet, gives an interesting and graphic account of the manner in which these fortifications were thrown up by the citizens of both sexes, working under a semi military organisation. He says :—

"The daily musters and showes of all sorts of Londoners here were wondrous commendable, in marching to the fields and outworks (as merchants, silkmen, macers, shop-keepers, etc.) with great alacritie, carrying on their shoulders yron mattocks, and wooden shovels ; with roaring drummes, flying colours, and girded swords ; most companies being also interlarded with ladies, women, and girles, two and two, carrying baskets for to advance the labour, where divers wrought till they fell sick of their pains. All the trades and whole inhabitants (the Insey* Courts excepted) within the citie liberties, suburbs, and circumjacent dependencies, went day about to all quarters for the erection of their forts and trenches ; and this hath continued these foure months past ; the half of which time I was a spectator to their laborious toyle, as after you shall hear. The greatest company which I observed to march out according to their turnes, were the taylours, carrying fourtie-six collours, and seconded with eight thousand lusty men. The next in greatnesse of number were the watermen, amounting to seven thousand tuggers, carrying thirty-seven colours ; the shoemakers were five thousand and oddes, carrying twenty-nine colours ; and indeed the gentle craft could never heretofore have mustered so many here since Crispus and Crispianus, the two supposed princes their patrones, forsook the trade. Neither in this catalogue dare I forget the porters that marched forth one day toward Tayburne Fields, carrying twenty-three colours, being three thousand white shirts ; and (*verbi gratia*) upon that same day a thousand oyster wives advanced from Billingsgate, through Cheapside, to Crabtree Field, all alone, with drummes and flying collours, and in a civil way, their goddess Bellona leading them in a martiall way. The next day following, May 17th, the felt makers, fishmongers, and coupers marched three several wayes to three sundrie fields, carrying twenty-four collours, had their number amounted to three thousand and odds.

"And now, to shun prolixitie, let the ingenious reader judge what number of numbers would these sequel trades be ; as goldsmiths, ferriers, bakers, bruers, butchers, cooks, candlemakers, smiths, cutlers, carpenters, shipwrights, joyners, boxmakers, wheelewrights,

* Inns of Courts.

turners, carvers, and four thousand weavers, braziors, dyers, imbroaderers, horologiers, watchmakers, engravers, tinkers, haberdashers, feather-makers, clothiers, tanners, curriers, glovers, spurriers, painters, printers, stationers, book-binders, gun-makers, glaziers, masons, tecturers, brick-makers, plumbers, upholsterers, combemakers, girdlers, coblers, chimney-sweepers, jack-farmers, with many more that I cannot recollect. Which indeed (as they are of a marvellous great number) so it was a delicate observation to consider and remarke the indefatigable multitude and strength of the city, never heretofore practised nor exercised; the computation whereof may facitly amount to an hundred thousand able men, not reckoning any above fifty years of age, although the latter number would far exceed the former."

APPENDIX B.

The following are the two sets of Articles concluded at Bristol on the occasions, respectively, of its surrender in 1643 and 1645. They are given as specimens of the conditions usually accorded, and may be considered examples of fair, and even favourable, terms to the defenders of a place, by besiegers anxious to obtain possession of it without further fighting. The spelling in these copies has been modernised, but no other change has been made in transcribing from the original documents, which are to be found in pamphlets of the time, existing in the unique collection made by the contemporary Thomason, and now in the British Museum. The articles of 1643 are to be found in the volume indexed E. 63, and those of 1645 in that indexed E. 301.

A Copy of the Articles agreed upon at the surrender of the City of Bristol between Colonel Nathaniel Fiennes, Governor of the said City, on the one party, and Colonel Charles Gerrard and Captain William Terringham, for and on the behalf of the Prince Rupert, on the other party, the 26th of July, 1643.

1. That the Governor Nathaniel Fiennes, together with all the Officers both of Horse and Foot, now within and about this City of Bristol, Castle, and Forts, may march out to-morrow morning by 9 of the Clock, with their full Arms, Horses, bag and baggage, provided it be their own goods; and that the Common Foot soldiers march out without Arms, and the Troopers with their Horses and Swords, leaving their other Arms behind them, with a safe Convoy to Warminster, and after not to be molested in their march by any of the King's Forces, for the space of three days.

2. That there may be Carriages allowed and provided, to carry away their Bag and Baggage, and sick and hurt Soldiers.

3. That the King's Forces march not into the Town, till the Parliament's Forces are marched out ; which is at 9 of the Clock.

4. That all Prisoners in the City be delivered up, and that Captain Eyres, and Captain Gookin, who were taken at the Devizes, be released.

5. That Sir John Horner, Sir John Seymour, Mr. Edward Steevens, and all other Knights, Gentlemen, Citizens, and other persons, that are now in the City, may if they please, with their Goods, Wives, and Families, Horses, Bag and Baggage, have free Liberty to return to their own homes, or elsewhere, and there to rest in safety, or ride and travel with the Governor and Forces; and such of them and their Families as shall be left behind, by reason of sickness or other cause, may have liberty, so soon as they can conveniently, to depart this Town with safety, provided that all the Gentlemen and other persons shall have three days liberty to reside here or depart with their goods, which they please.

6. That all the Inhabitants of this City shall be secured in their Persons, Families, and Estates, free from plundering and all other violence or wrong whatsoever.

7. That the Charters and Liberties of this City may be preserved, and that the antient Government thereof and present Governor and Officers may remain and continue in their former condition, according to his Majesty's charter and pleasure.

8. That for avoiding inconveniences and distractions, the Quartering of Soldiers be referred or left to the Mayor and Governor of the same City for the time being.

9. That all such as have carried any goods into the Castle, may have free liberty to carry the same forth.

10. That the Forces that are to march out are to leave behind them all Cannon and Ammunition, with their Colours, and such arms as is before expressed.

Articles of agreement between the Commissioners appointed on the behalf of His Highness Prince Rupert, and His Excellency Sir Thomas Fairfax, for the Surrender of the City of Bristol, September the tenth, 1645.

That His Highness Prince Rupert and all Noblemen, Commanders, Officers, Gentlemen, and Soldiers, and all other persons whatsoever now residing in the City of Bristol, the Castle and Forts thereof shall march out of the said City, Castle, and Forts thereof, with Colours, Pikes, and Drums, bag and baggage. The Prince, his highness, all Noblemen, Gentlemen, and Officers in Commission, with their Horse and Arms, and their servants with their horses, and swords, and Common Soldiers with their swords. The Prince his life Guard of Horse, with their Horse and Arms, and two hundred and fifty Horse besides to be disposed by the Prince, and his life guard of Firelocks, with their arms, and each of them one pound of powder, and a proportion of Bullet, and that none of the persons who are to march out on this Article, shall be plundered, searched or molested.

That such Officers and Soldiers as shall be left sick or wounded in the City, Castle, or Forts, shall have liberty to stay till their recovery, and then have safe conducts to go to his Majesty, and in the interim to be protected.

That the persons above mentioned who are to march away, shall have a sufficient Convoy provided for them to any such Garrison of the King's as the Prince shall Name, not exceeding fifty miles from Bristol, and shall have eight days allowed for their march thither, and shall have free quarter by the way, and shall have two Officers to attend them for their accommodation, and twenty waggons for their baggage, if they shall have occasion to use the same.

That all the Citizens of Bristol, and all Noblemen, Gentlemen, Clergymen, and all other persons, residing in the said City and Suburbs of the same, shall be saved from all plunder and violence, and be secured in their persons and estates from the violence of the Soldier, and shall enjoy those Rights and Liberties which other Subjects enjoy under the protection and obedience of the Parliament.

That in consideration hereof the City of Bristol, with the Castle and all other Forts and Fortifications thereof, without any slighting or defacing thereof, and all the Ordnance, Arms, Ammunition, and all other furniture, and provisions of War, excepting what is before allowed, shall be delivered up to Sir Thomas Fairfax, to-morrow being Thursday the eleventh day of this instant September by one of the clock in the afternoon, without any diminution or embezzlement, his highness Prince Rupert then Naming to what Army or Garrison of the King's he will march.

That none of the persons who are to march out on this agreement shall plunder, hurt or spoil the town, or any person in it, or carry out anything, but what is properly their own.

That upon signing these Articles, Colonel Okey and all persons now in prison in the City of Bristol, the Castle, or Forts of the same, shall immediately be set at liberty.

That sufficient Hostages be given to Sir Thomas Fairfax, such as he shall approve this night, who are to remain with him, until the City be delivered.

That neither the Convoy nor Officers sent with the Prince shall receive any injury, in their going back or coming back, and shall have seven days allowance for their return.

That upon the delivery of the town, sufficient hostages be given for performance of the Articles on both parts.

Signed by us the Commissioners on the behalf of his Highness Prince Rupert.

Jo. Mynn.
W. Tillyer.
William Valvasor.

Signed by us the Commissioners appointed on the behalf of his Excellency Sir Thomas Fairfax.

Edw. Montague.
Tho. Rainsborough.
Jo. Pickering.

APPENDIX C.

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*A Description of the Seige of Basing Castle kept by Lord Marquisse of Winchester for the service of His Majesty against the Forces of the Rebells under Command of Colonell Norton, Anno Dom., 1644. Oxford: Printed by Leonard Lichfield, Printer to the University, 1644.**

Basing Castle, the Seat and Mansion of the Marquisse of Winchester, stands on a rising ground, having its forme circular, encompassed with a Brick Rampart, lyned with earth and a very deep trench, but dry; the loftie Gate-house with foure Turrets looking Northwards, on the right whereof without the compasse of the Ditch a goodly building containing two faire Courts; before them is the Graunge, severed by a Wall and common roade, againe divided from the foot of Cowdrey's Downe by Meades, Rivilets, and a River running from Basingstoake, a mile distant upon the West, through Basing Towne. Joyning upon the East, the South side of the Castle hath a Parke, and toward Basing Towne a little Wood, the place seated and built as if for Royaltie having a proper motto, *Aymey Loyalte.* Hither (the Rebellion having made houses of pleasure more unsafe) the Marquisse first retired, hoping integrity and privacy might have here preserved his quiet; but the source of the times villany, bearing down all before it, neither allowing newtrality or permitting Peace, to any that desired to be lesse sinful then themselves, enforceth him to stand upon his guard which with his Gentlemen Armed with six Musquets (the whole remainder of a well furnished Armory) he did so well, that twice the enemies attempts proved vain.

But finding their numbers in those parts (after their Losse of Reading) grown more formidable, their forces quartering round

* "Thomason Collection," vol. 191 (E 27), No. 5. Thomason notes on title page the date of publication "In Feb.," *i.e.*, 1644-5.

about him, he solicited His Majesty for one hundred Musqueteers, which (being sent under command of Lieutenant-Colonell Peake) marching with speed and secrecy the 31st July, 1643, were thrust into the place, which from that time became a Garrison; it's former fortune still continuing, Colonell Harvey and Colonell Norton, within a few houres after attempting to surprise it, being not only beaten off, but the same night forced retreat to Farnham.

The place is then begunne according to the quantity of men now added to be fortified, and some time after upon report of a puissant Army, under command of Sir William Waller, to be appointed for the taking of it in, Colonell Rawdon, with the rest of his Regiment (being about one hundred and fifty more), is commanded thither. The Lord Marquisse taking forth Commissions as Colonell and Governour for the raising of more forces for defence of the same.

November 6.—Shewes Waller with the expected Army (consisting of seven thousand Horse and Foot) before the House, where having lyen nine daies, and three times storming it, he again retires to Farnham, having dishonoured and bruised his Army, whereof abundance were lost without the death of more then two in the Garrison, and some little injury to the House by Battery. He thus drawne off, and His Majesties Army, under command of the Lord Hopton, advancing two daies after, affords the Liberty of farther fortifying, which thus (as time and number would permit) made up, is rather strong then Regular.

The ensuing Spring the Rebells, as well consulting the importance of the place, as the injuries suffered by it, both in their Trade and Force, resolve (having before assayed it by Surprize and Storme) to try by starving it, to which their Armies, six weeks Quartering at Farnham, Odiam, Grewell, and Basingstoake, was a preparative, harrowing the Country about until their March to Oxford.

June 4, 1644.—At what time Colonell Norton drawing some forces from the adjacent Garrisons, by order of their pretended Parliament, is to block up the House, and (by the treachery of a Soldier giving intelligence two daies before) defeating a party of the Garrison drawn out to Odiam, and taking divers Prisoners upon the fourth of June, faced the House with a Regiment of Horse and Dragoones, and after some hours stand Quartered in Basinstoake, each day (his Foot not yet come up) keeping his guards of Horse upon our Avenues to stop the fetching in Provision.

June 11.—Colonel Morleye's Regiment of sixe Colours of Blew from Sussex, and Sir Richard Onslowe's Regiment of five of Red from Surrey, with two of White, from Farnham, and three fresh Troops of Horse fetched in by Norton's Regiment, are all drawne up before the House, upon the South of Basingstoake; the Companies of White at Evening, with one Troop of Horse, marching to Sherfield, Sir Richard Onslowe, with his Troop of Horse to Anwell House, and Morleye's Foot with Colonel Norton's Horse quartered in Basingstoake. During the time of lying at this distance, visiting us with horse (with whom entertaining skirmishes at their returne) were usually made worse with little losse to us.

June 15.—To see the countenance of the Enemy, fifty foot are sent toward Basingstoake, under the covert of a mill and hedge, whilest our Horse forced theirs into the Towne, they reenforced, ours orderly retreat, drawing them on in danger of our Foot, who galling them, they stand the comming of their owne, 'twixt whom some vollyes being spent, ours are Commanded in.

June 17.—The Enemies horse seize on two Teemes of ours, fetching Provision towards Sherfield, and three horses grazing in the Parke. At night the Companies of white quarter in Basing Towne, and fortifying the Church, next day from the adjoining houses shot two of our men; and being now come here, our numbers few, we divide our men into three parts, keeping two thirds on duty, whilest the other rest, appointing to each Captaine and his Company a particular Guard, dividing the Quarters of the Garrison to the Field Officers, viz., to Major Cuffand, the workes adjoining to the Parke; to Major Langley those in the gardens; to Lieutenant-Colonell Johnson, the care of the Graunge; to Colonell Rawdon, the workes next the Towne; and dispose of the Guns to Lieutenant-Colonell Peake; the Troopers fitted with Muskets, and part of his Foot Company as a Reserve for supply of all places as any need required; the Lieutenant-Colonells and Majors by course being Captains of the watch, Colonell Rawdon onely in this excused by reason of his years.

June 18.—The Regiment of Blew, from Basingstoake, relieve the White, on whom at midnight sallying forth, we Fired one of the houses which annoyed us; but the next night sallying againe, we Fired all between us and the Church, themselves at same time Firing some beyond, by which their workes growne hot, some flye into the hedges, others further off. But at the ringing of the Bells (their custome upon all Alarmes) reliefe comming on all sides, ours retreat; they that night Quartering round the Parke under the favour of the hedge and pale, where they continue till next

Evening, and with continuall Firing Kill us one Sentinell, and hurt another.

June 20.—The following day, the Parke being cleared, and they returned to quarter, and their guard at Church, our Horse are put into it and 12 Musqueteers lodged at the corner of the Lane in covert of the hedge, some Officers of theirs thinking the Lane secure are blooded from the hedge and hardly scape to Basingstoake, our Horse persuing them, and whilest their guard on Cowdreye's Downe perceiving it, Troop to their rescue ; ours are recalled, and sent up by the Graunge to Fire their Quarter, which is done, and one of them brought in ; at same time more of theirs riding along the Lane our Musqueteers killing the horse of Colonell Greaves his Brother, take him Prisoner, the Colonell and the rest escaping to persue their Journey to the West. Two howers after a Trumpet is sent in from the Colonel to demand his liberty, under pretence of being a Traveller, but is returned with a proposall of Exchange, next day two of Sir Richard Onslowe's Foot are taken in the Parke, and a third killed.

June 24.—Finding a sufferance by our Liberty resolving now more streightly to begirt us, two companies more from Portsmouth, being joined to those of Farnham in the Towne, the Regiment of Blew is drawne into the Parke, and Colonell Onslowe's to the Lane and close towards Basingstoake, where having fixed their quarters, they presently breake ground, shutting us up on three sides with their Foot, and on the other side their guards of horse keeping on Cowdreye's Downe, at night busying themselves with Spade and Pick-axe to secure their Quarters, three of ours runne to them.

June 26.—Some Musketeers are sent by the point of Basingstoake (a Bulwarke) to view their lodging in the Lane, and to cut downe some Trees blinding a ruined Mill, from whence they played on us, both which are done and divers of them killed, with losse of two of ours. At night they ran a Line toward the Mill, where we had galled them the day before, next night a Party of horse Firing upon their Sentinells on Cowdreye's Downe, much amuse their guards, whilest others of them are sent by to Oxford.

June 29.—Their worke in the Parke is brought to some perfection, and by noone their Cannon Baskets placed make knowne they had a Culverin there, giving us sixe shot thence. Next day being Sunday (their Cause allowes not now for Sabbath) doubling their diligence throughout the Leaguer, forwarding the Sconce at Morleye's Quarters in the Parke, and on the Towne side towards a

Mill, drawing a Line from the Church. At Onslowe's Quarter, raising a platforme in the Lane with so much speed, that the next morning a Demy-Culverin playes from it; at night our Messenger from Oxford informing us His Majesties successe against Waller and Cropready. We Ecchoe it to our neighbours with Volleys, both of small and great, they answering with their Guns, battering our Kitchen and Gate-house, till a shot from our platform spoyling the Carriage, silenced their Demy-Culverin.

July 3.—Their Lines being run within halfe Musket shot by their continuall Firing powering their Lead into the Garrison, they spoyle us two or three a day, passing within our workes, and shoot the Marquisse himselfe through his Cloathes, the Carriage of their peece being repaired, they now renew their Battery on the House unto the detriment and topping of our Towers and Chimnies.

July 8.—This morning they essay to draw us forth by making an Alarme to themselves (leaving their piece neglected without a guard) but faile; at Evening a Prisoner escaping from them under the hazard of 100 shot so chafed them that they continue Firing untill midnight, and shot two of our men next morning. Foure Companies of Red, from Surrey, comming to the reliefe of Colonell Onslowe's men, marching too neare, have three shot placed amongst them from our Minion, making them change their march to Troop at further distance.

July 11.—One Company from Southampton of seven score, marched by the way of Hackwood unto Hollowaye's Mill, with which (and those foure Companies come in two dayes before) Morley is now so raised in his hopes that making use of Colonell Norton's absence (ambitious of the honour, but of summoning the next day being our Fast adding to our afflictions) sends by a Drum this harsh demand :—

My Lord,

To avoid the effusion of Christian blood, I have thought fit to send your Lordship this Summons to demand Basing House to be delivered to me for the use of King and Parliament; if this be refused the ensuing inconveniences will rest upon your selfe, I desire your speedy answer and Rest, my Lord,

Your humble servant,
Herbert Morley.

The Marquesse, upon small deliberation, return'd Mr. Morley this Answere :—

Sir,

It is a crooked demand, and shall receive its answer sutable, I keep the house in the right of my Soveraigne, and will doe it in despight of your Forces; your Letter I will preserve as a testimony of your Rebellion.

Winchester.

This answer being return'd by the Dawn with a *Hast, hast, hast, post hast* upon the Letter, Morley speaks his choller from his Gunns, which now and some daies following played on our Waterhouse; Colonell Onslowe's men courteously permitting eight of our Foot to fetch six Beasts grazing before their Workes. At night Coronet Bryan, and some Troopers, passing a Messenger by Cowdrey's Down, bring in two Prisoners.

July 18.—A Bonfire in the Park, with two Volleys throughout their Leaguer, speake their Committee's welcome unto Basingstoake.

July 20.—A party of our Musquetiers fall out upon them in the Lane, and having done some execution there, retreat; a Captain of Colonell Morley's being shot dead at same time from our works; two hours after comes a Drum with Letters for exchange of Prisoners, but rather to informe us Norton's safe returne from the defeat of Waller, and gain time to draw a Morter-peece more covert to their trench; from whence (their Drum return'd) they send us a granado of 80lb. next night, concluding their devotion and the day with thundering from their Culverins, two passed through the Quarters where our sick men lay, but without hurt.

July 22.—Their Lines are much advanced, and their Sconce flanking their Battery in the Parke finished, the Marquesse himself hurt by a shot, and two men killed by chance shot, and the Carriage of our Cabonet broke from their Culverin. The following night being darke and stormy, we dispatch out Messenger. Eight Prisoners taking the opportunity doe the same for themselves to their Leaguer making our allowance of great shot to be next day doubled, and at night more Granadoes.

July 25.—The trenches on the Towne side in the Meades flote with the quantity of raine that fell, thereby forcing them, lye more open to our Towers from whence our Markes men spoyled divers, whilest on the other side our men draw covert to a Blind, and doe as much upon them; in the Lane at night two peeces charged with Case, so luckily are placed upon them (working upon their Lines) that they were heard complaine their suffering.

July 26.—Early this morne the Blind againe being manned, an Officer with more of theirs are killed, and a Trooper of our owne afterward fetching a Hog and Cowe neare the same place occasioning some service from the Blind and Bulwarke they receive more losse. The Evening spending with dispute between our great Guns, they adde sixe Granades, one falling in our Granary, spoyled some Corne, and two missed Firing; at night two soldiers run to them.

July 27.—This morning shewes a traverse Crosse the Close from the burnt Mill, flanking our way unto the aforesaid Blind, and in the Parke the enclosing of the nearer side of an old Orchard securing Morleye's Quarter. At night from out their Morter peece, they shot us sixe great stones sized with the granades of 36lbs., with each day continuing like allowance, these and the granades for a while seemed troublesome, but afterwards become by custome so familiar to the Souldier, that they were called, as they counted them, *Bables*, their mischiefes onely lighting on the house, and that the lesse, our Courts being large and many.

July 30.—They plant a Culverin by Basing Church, from thence battering a Tower, on which our Markes men stood, that much annoyed that Quarter, continuing shot from both their other platformes. This day ends the yeare of the places being Garrison'd, and the second month of the Leaguer, next day a platforme is begun by the Wood side, within halfe Musquet shot of Basing Bulwarke. Towards Evening paying the shot (it having been their Fast) they spared all the day. At night running a trench from the Church to their worke by the Wood, and (by foure men which last night run to them) perswaded of strange executions done by stones and Granades send us store, one whereof Firing our Hay falling into the Barne, had done much hurt had not our diligence soon quenched it.

August 1.—Our men tyred with length of 48 hours duty are now divided into two parts relieving every 24 ; our Gentlemen and Troopers doing the same, and here I cannot passe them over without due Commendations, all the time of the Leaguer undergoing the duty of Foot (that of Sentries only except) going forth in all Sallies as well on Foot with Musquets or Browne-Bill, as otherwise on Horseback, as occasion was ; and for seven weeks time keeping their Horses with grasse and Sedge, which in the night, they cut under Command of the Rebells workes with hazard of their lives.

August 4.—Perceiving the intention of the Rebells rather to starve then storme us, and the doubt of a more potent Army now removed, which hitherto had made us frugall of our men (already few in number and much spent out with labour) as well to animate our men dismayed through divers wants and the raigning of the pox,* as also to annoy the Rebells, retard their workes, and gaine by Prisoners somewhat of their condition. We resolve upon advantages to make some sallies, and finding then an opportunity, a

* This was the small pox.

party of their Foot lying at hazard upon Cowdrey's Downe in Waller's work, Lieutenant Cuffand, with about 20 horse, is sent to fall on them, Whilest Coronet Bryan with like number riding at rate, is to cut in betwixt them and the hedge, where stood their guard of Horse, who seeing themselves thus unexpectedly charged, suddenly rout, flying to Basingstoake, and are pursued with execution on them, almost to the Towne, the Coronet bringing in their colours, Trumpet, seven Horses, and three Troopers, besides what slaine and maimed; of the Foot eleaven killed on the place, and foure brought in; our men returning under Command of their Cannon without the losse of a man. At first of the Alarme, they apprehending it, a Party with reliefe began to flye the Parke till informed better, and again returning, they spend their heat at distance with their Guns and Mortar-peece, we learning from the Prisoners their intention to batter upon Basing-Bulwarke from their new platforme by the Wood, lay on all hands for Lyning it, as yet being very weak there, labouring without enforcing us to doe the like within our workes, in many places slender and no where furnished, of which defects our Renegades giving them information necessitates us worke to frustrate their reports.

August 5.—Their guarde at Waller's worke is doubled, and strengthened with Pikes, keeping their guard of Horse by exercise in better readinesse. In the Parke side their Lines advance toward both our platformes, and their worke by the Wood forwarded, liberally bestowing great Shot, Stones, and Granades, of which they send us of three severall sorts, besides their hand Granades.

August 10.—Colonell Whitehead's new raised Regiment of five Companies, marching through Basingstoake to Cowdrey's Downe, take up their Quarters in the Delve, for whose welcome and entertainment (with some sport) they founder a round Tower in the old Castle, by their Battery; in requitall whereof next morning, Major Cuffand with 6 Files of Musqueteers and 20 Troopers with Browne-Bills falling into the Parke, attacque their outward Lines, where killing some of them, burning their Blinds and Baskets, they bring off one of their Mortar peeces and store of Armes and Tooles; with having two men hurt. Lieutenant Snow, with 20 Musqueteers and 12 with Bills during the amazement falling upon their Quarter in the Lane with execution on them, breaking their Demy-Culverin, Firing their guard and Baskets, and from hence with Armes and Tooles bring in some Ammunition. These Sallies were so much unto their losse, and touch so neare their honour that Oram (Captain of the

Guards) for vindication must be brought to tryall, and for neglect and cowardise (running as others then and after did) holding correspondence with the place (where no man knew him) and sending in Ammunition (which was never received) with the hazard of life is Cashiered their service. A sentence much like that against the Earle of Stafford made with caution not to be brought to president for after times, least it too nearly might concern themselves. At night provision for our Horse being spent, we make a worke beyond the Graunge neare the Foot of Cowdrey's Downe, securing the Meades for our Troopers in darke nights to fetch in grasse.

August 12.—We see them busied making provision of Baskets, Brush, and Turfe, to goe on with their workes, which for some daies lay still, filling their Baskets now with grasse to save their firing, and in the meane time ply their Culverins.

At night an Alarme beating through their Quarters, we expect according to the noyse, but they stay quiet till between three and foure, what time a Trumpet sounding on Cowdrey's Downe, from forth the Delve they fall upon us, busied at our new worke with 50 Musquetiers, but soon draw back; at same time 60 more by favour of a Wood, had gotten to the ditch under our platforme, where fired on by the Guard in the Parke Bulwarke flanking the ditch, they returned in hast leaving some Armes behind, having three Guns with case shot powred on their reare, for which they send us plenty from their severall Guards. And now begin a trench unto the Parke from the Lane side, the better to secure that quarter, running it toward their great Work, meaning to close their Lines throughout their Leaguer. Next day they spare their great shot, but at night gave us a false Alarme.

August 14.—Towards evening Lieutenant Cuffand and Cornet Bryan, each with twenty Horse and forty Musquetiers, Sally upon the Downe againe, beating the Foot upon Waller's worke, and the Horse Guard from their Post, pursuing them to Basingstoake, whence strengthened with fresh Horse, they force ours to retreat, take Cornet Bryan and one Trooper, wound three others, and Kill Ensign Amery, ours having done abroad good execution bring in Lieutenant Cooper, a Corporall of Horse, and seven more of theirs; from whom we learne, Morley foure dayes before was shot in the shoulder viewing his workes in the Parke. The two next dayes were spent in Parlee for release of Prisoners. They sending us one wounded, we returne them three, offering Lieutenant Cooper and the Corporall (both stout men, wounded, and taken fighting) for our

Coronet, but would not be accepted, so much they valued him; the Parlee ended they play as formerly, at night sending three Granades, whereof one failed them.

August 17.—They bring Baskets to Waller's worke, and the Delve where they had wrought the former dayes to raise a Battery, and to secure themselves, learning our Sally intended the beating up that Quarter, and had been done, had not our Horse pursuing them too farre, engaged our Foot to secure their retreat; for at the first they ran, carrying their Colours with them from the Delve, though 300 men were said to Quarter in it, but animated with coming in of more, and drawing to the hedges in the Meade some Musquetiers from Holloway's Mill, they againe make good the place streightening our Horse retreat; at Evening planting a Culverin there, they play from thence, and from the peece at Church, this night three run to them, and one the night before.

August 19.—This day getting their Demy Canon to the worke by the wood, they batter us, with 48 shot; and the two following dayes with eight score more, the least whole Culverin, with which and with Granades they killed two men, and mischieved two more, break our best Iron Gun, and make a breach in one of our square Towers. The injury of the worke before it, the Officers and Soldiers putting hand to Spade repaire, making it Canon proof, before scarce Darke.

August 22.—This day they are more sparing, and permit the night enjoy its proper silence, disturbed onely by such, whose basenesse prompted them with hope to gaine by craft, what by their force they could not, shooting Notes fixed to arrowes with proffers of preferment to the Souldier, perswading Mutinies, and labouring divisions 'twixt the Regiments, leaving no stone unturned; but all in vaine, except the gaining some faint hearted Knaves. The following dayes sending of Crosse barre shot, Logs bound with Iron hoops, Stones, and Granades, whereof two missed firing. Two more run to them.

August 25.—Their Battery neare the Wood having much torne the Tower, they now begin on that side next the Towne, within Pistoll shot to make a worke, to batter it from thence. In the meane time continuing shooting from their other Guns, they kill two men and maime a third; and in the Parke they shew a Sowe made for their Musquetiers, thrusting before them for to play behind; this night two run to them, and next night foure; inforcing us to seasonable justice in executing one who attempted to have gone with them, by which our Souldiers were so fastned, that for a long time not one man that stirred, though our necessities grew fast on us, now drinking water, and for some weeks past making our bread, with Pease and Oats, our stock of Wheat being spent.

August 28.—The Lines from Onslowe's Quarter are brought on with a redoubt upon it, opposite to Basingstoake Bulwarke, and having broke their Culverin, at the Delve, supplying it they play againe from thence, and in the night steal off five Horses grazing in the Meades; next night two Troopers cutting grasse, our River by the Mill being drawne downe, enforce us make a Damme raising the water to secure the Graunge.

September 2.—At noone with Letters for Exchange of Prisoners we receive this summons:—

MY LORD,

These are in the name and by the authority of the Parliament of England, the highest Court of Justice in this Kingdome, to demand the House and Garrison of Basing, to be delivered to me to be disposed of according to Order of Parliament. And hereof I expect your Answer by this Drum within one howre, after the receipt hereof, in the meane time I rest.

From the Quarters before Basing, the 2 of Sept., in the afternoone.

Yours to serve you,
RICH. NORTON.

To which the Lord Marquesse instantly dispatch this Answer:—

SIR,

Whereas you demand the House and Garrison of Basing by a pretended authority of Parliament, I make this Answer, That without the King there can be no Parliament, by His Majesties Commission I keep the place, and without his absolute Command shall not deliver it to any pretenders whatsoever, I am.

Yours to serve you,
WINCHESTER.

Basing, 2 Sept.

This Answer sent. From their new Battery by the Towne in sixe houres time they thunder six score shot Cannon and Culverin; with which they Founder one of our great Brick Towers, from whence we had annoyed that Quarter, their small shot playing thick this day, they kil'd us three, and hurt a woman.

September 4.—The rubbish of the Tower filling the end of a Curtain under it, we cut off the other by a traverse, lyning the Bulwarke where their shot had run; next day their great shot is reduced to 20; their Cannon by the former heat being made at fault, is this day drawne to Farnham. The night brings on their Line at Graunge, blocks up our way to the Downe, and slights the worke we had made, by us some dayes before deserted, now growne too hot and wanting men to keep it.

August 4 (*sic*).—The day of promised reliefe our men in readinesse. Noon came and no appearance of them, unwilling to be idle, we resolve a Sallie ; Lieutenant Snow, Lieutenant Byfield, and Ensigne Outram, each with 12 Troopers, with Brown Bills, and 18 Musqetiers are sent at once to fall on Onslowe's Quarters in three parts, which is so well performed, that gaining their redoubts, they draw their Demy-Culverin neare our workes, bring but three Prisoners in, our Gaole being full, and having lost three men by the Enemies Case shot, and one hurt, retreat; the great Guns being plyed on both sides, some of ours luckily fell upon them at the Delve. Sir William Waller with two Troops of Horse, two hours before arrived at Basingstoake, came forth to see the sport, and with his Horse facing the House too neare on Cowdrey's Downe, they had their Captain killed with round shot from our workes. In this dayes service, by confession of our Enemies, they had 60 common Souldiers killed, and 12 dangerously wounded, besides two Gunners and two Lieutenants, one whereof belonged to Sir William, and brought by curiosity to see the Leaguer was there slain ; of ours besides the former we had three sleightly hurt with dirt beat up by Culverin shot. At night we endeavour to fetch off the Gun, but find it heavy, they having doubled Guards, we place 12 Musquetiers to wait the engaged peece. This day and next spends 50 shot from their new platforme, by battering downe a stack of Chimnies, making a large breach in the new building ; toward night we see two Companies of Foot marching by Hackwood Westward, followed next Evening by two Companies more, two Waggons and twelve Troops of Horse. Next day againe at noone ceasing their Battery, permit us to see two Regiments of twenty Companies follow the Horse had passed, two companies of White turne into Basingstoake, and their Artillery, ten of severall sorts conveyed by one Company more of Yellow. This night we expect Alarme, and were well prepared having for foure nights since kept all our men upon duty. But it passeth without disturbance, more then that of tongues, boasting their Army to be next day shewed us, which Sir William's hast unto the West permits not. And well satisfied with Wednesdaies Sally, the strife for plunder of the house maintained with so much pertinacy between his men and Norton's ceased, and we againe with our old guests are left to try it out, grown now so mute upon this parting, as in 48 houres we hear but of two Culverine shot, next day recovering heart, they tell us 22, and resting some daies past, now find their worke againe.

September ·11.—Silent till towards evening, ten great shot ; at night our Messenger, Edward Jeflery assures the certainty of our reliefes advance to Aldermarston, and taking of some Scouts, we then make fires upon the Gatehouse in signe of notice, and of readinesse, though (through the Fogge) it hardly could be seen to the next hill. By seven next morne, the Noble Colonell Gage with Horse and Foot past through so many hazards, had attained Chinham Downe, where Colonell Norton with his strength having intelligence did stand in readinesse. And now what here was done I shall referre to what hath been said by others from some one present there, which may relate to each his due desert, in all so much. That notwithstanding all advantages of place, and men fresh and prepared against tyred Troops and wearied Foot, a Fogge so thick as made the day still night, helping the shrowding of his Ambuscades, and clouding passes unto such who neither knew nor could discern a way more then their Valour and the Sword did cut, and Maugreall, with execution forced his retreat the Fogge befriending him serving as covert, for his safer flight through Basingstoake,* the day then clearing, and report of fight brought near the Garrison, Lieutenant Colonell Johnson with some Musquetiers issuing by the Graunge, beats them from off their Line, pursues them to the Hill, and thence unto the Delve, cleering that Quarter with small defence as is incredible. The passe thus cleared meeting our welcome friends our joys are ecchoed, whilest the sad Prisoners are led in to see the House they lay so long about, their number 64 Common Souldiers, two Sergeants, one Lieutenant, whereof the wounded were next day sent forth unto the care of their owne Chirurgeons, and two that ran from us had execution. The Ammunition brought put in, and the Lord Marquesse visited by his worthy friends, they return to Cowdrey's Downe; whence the Horse under some hazard of the Enemies Guns retreat to Chinham, thence 100 Musquetiers being sent unto the House, they march through Basingstoake, facing the Rebells workes whilst 14 barrells of powder and 100 Armes found in the Towne, and what provision of all sorts could be got, were sent into the garrison, where 100 Musquetiers under command

* Gage's own account of his expedition is given in full in Walker's "Historical Discourses," pp. 90-95. He left Oxford on the night of Monday, the 9th September, and arrived within a mile of Basing between 4 and 5 a.m., on Wednesday, the 11th. This relief by Gage was one of the most brilliant actions of the War and worthy of comparison with similar actions in any war. Clarendon says of it (Book VIII. "History of the Rebellion,") "it was confessed by Enimies as well as Friends that it was as Soldierly an Action, as had been performed in the War on either side." Gage was Knighted at Oxford on the 1 or 2 November (Symonds), and succeeded Aston as Governor o Oxford.

of Major Cuffand, seconded with the number of supplies led forth by Captaine Hull, attacque the line on Basing side, take in that quarter and the Church which they had fortified. In it 2 Captaines (Captaine John Jephson and Captaine Jarvis), 1 Lieutenant, 2 Sergeants, and about 30 Souldiers the rest by severall wayes escaping. During the former fight their Guns being drawn from off that platform to their workes in the park ; Sir Richard Onslowe's quarter towards Basingstoake, that fatall place againe is taken in the skonces sleighted ; and their peice brought in by Musquetiers, led by Lieutenant-Colonell Peak, their Tents and Huts fired neere Holloway Mill, the Enemy so hastening from these workes as scarcely 3 could be made stay the killing.

Thus might we see at once, three of their Quarters blaze, onely one (well fortified and their remaining strength drawne in) is left them quiet.

September 12.—The next day is employed in sending warrants forth, fetching provision from the adjacent Townes, and getting in a Culverin the enemies hast had left neere to the wood, which they permitted us with so much tamennesse, as called our men to fall upon their workes, but most part of our Foot then busied abroad these are commanded off having a Sergeant and 5 others shot, whereof they after died, care being taken for such Gentlemen of our reliefe as had been hurt, night coming on, intelligence of enemies appearing from the townes neere Silchester and drawing towards Kingscleare, Colonell Gage ordering his horse and foot to be in readinesse, having supplied the Garrison as much as shortness of his stay gave leave, about 11 at night takes Conge of the place, marching the way of Reading, leaving the enemy next morne amused with a letter for exchange of Captain Love for Jephson, which by noone was done ; and they by it assured the certainty of his retreat to Oxford.

September 14.—The towne of Basing not yet repossest a hundred musqueteers are sent under command of Captaine Fletcher to guard our carts fetching provision thence, on whom the enemy with horse and foot falls out toward evening, Norton himselfe there present, ours taken in disorder are beat back, but soon restored by the comming forth of the field officers, and they forced back into their workes, sixteen of them being slain in the retreat and eleven taken ; of ours an ensigne and two common souldiers killed, six hurt, whereof four dyed, and eight made prisoners ; Lieutenant-Colonel Johnson, Doctor of Physique, was here shot in the shoulder, whereby contracting a feaver, he dyed a fortnight after, his worth challenging funerall teares, being no lesse eminent in the garrison for his valour and conduct as a souldier, than famous through the kingdom for his excellency as a herbarist, and physician. The following week keeping the towne with guards, we fetch provision, sleight their platforme, and throw down their workes without the least alarm.

September 23.—The rebels again falling upon our guard in towne, ours are commanded in, having replenished our store for some weekes time, and wanting men to spare. The church by them thus repossest, they now enlarge themselves and keep us to our workes, of late too loosly growne familiar in the towne. This day two gentlemen of our reliefe was exchanged from Reading for three of theirs with us. Next day a party of our Horse are sent forth by the Grange to face their guard on Cowdrey, whil'st our foot draw in twenty fat hoggs from of the Downe, their scouts draw back unto their Guards, kept near to Basingstoake, whence strengthened, ours orderly retreating, are pursued neer to a hedge lyned with our musqueteers, who salving them, they quickly face about, having swormd out the number of 5 Troopes. The morrow entertaines them in like manner, whilst our men spoyling their platform at the Delve, bring in their planke and timber.

September 27.—Some of our Horse sporting on Cowdrey's Downe, and there amusing them, six others through the Park Lane toward Basing-stoake fetch in eight of their foot passing unto their Leaguer; and a water leveller imployed for the drawing of our river; Morley himselfe hardly escaping them, causing some foot come forth to stop our horse retreat, are galled by our musqueteeres purposely lodged in covert. An houre after we receive a drum from Colonell Norton, for the sending out some gentlemen to treat the change of prisoners, and is returnd without fixing of a day.

September 29.—The stage of Cowdrey furnish'd again with actors, a coronet and three more of theirs are killed and one of ours. At night (the morrow being a faire at Basingstoake) six Foot with pistoll and Browne Bill are sent to try the market, and foure miles off at a committee's house finding to serve their turne, from thence bring in twenty-three head of cattle by the Delve, which passe our daily skirmishing kept free, nex day informed the enemy imploed in fortifying the church, sometimes kept but a carelesse guard, 100 musqueteeres led forth by Major Cuffand are sent to force the place, and having gained a worke, wanting wherewith to force the doore, theirs comming fast to rescue, ours retreat, having a sergeant and six souldiers shot in the attempt, whereof most dyed ; of theirs an ensigne and some others slain.

October 2.—We send forth Captain Rosewell and Captain Rigby, secur'd by hostages, with instructions to treat release of prisoners. The same night M. Greaves and Captain Jarvis, next day two lieutenants with diverse more sent out, receiving Captain Rowlet, a lieutenant and two sergeants lost at Odiham, and some daies after Coronet Bryan and three gentlemen of our releefe released to Oxford.

October 4.—This and the eight daies following, our Horse and theirs change pistolls upon Cowdreys Downe, they having number, we advantage of a hedge with musqueteers, so as the odds was ours, and three or foure of theirs was daily carried off, we all the while loosing one horse and two foot souldiers, at night send forth our chapmen well furnished and good market folkes, in five houres time returne with twenty-five beasts under the noses of their sentinells, some Musqueteers of ours lying abroad for their security.

October 17.—Past noon from off our towers, we see the van of Manchester's Army to Basingstoake and Sherfield ; next day some of his horse visit the Leaguer, and by our Markesmen two of them are shot, the following day eight Regiments of Foot and some of Horse with all their Carriage and Artillery, drawn on the South of Basingstoake facing the House, make halt some houres, and towards night returne into the Towne, most of their Horse which all the day had stood at two miles distance neere Rooks downe, at night with hast enough Troop to their Quarters towards Farnham.

October 20.—Three Foot Souldiers comming too neare to see the House receive the curtesy of fetching in, and next day by our Foot in Ambush in the lane a Cornet of Sir Williams' Regiment and two Dragoones were taken, our horse from off the Hill fetch in two stragling Foot, at noon some Regiments of Horse and Foot belonging to the Earle of Essex, joyne to the Leaguer, their Army toward evening drawn in Battalia, that night keep the field, the Van neare Rooks Downe, the Battle at Basingstoake, and Reere by Hackwood next day Marching the Army towards Reading, the Foot by Sherbone, and the Horse keeping along their left, the following day three Troopers more brought in, keeping our Horse abroad to wait on them. At night part of a ruined Tower falling by Tempest on five of our men, killing one, and somewhat bruised the rest.

Lieutenant Cuffand with some 40 Horse charging their Guardian (? guard on) Cowdrey's downe, spoiling five Horses and as many men, takes one of theirs, with losse of one of ours; next day facing their Horse again, whilst Coronet Bryan with some few Horse fetcht off a Load of Corne, driving neere to their Guard. And riding through the Garrison from off th'other side, brings in a Cart and Teame passing to Basingstoake. These Carts did help us in 3 following nights, secured with Convoyes to fetch in 5 quarters of thresht corn, and 12 loads in the sheafe from Piats hill, the same nights furnishing us 14 Beasts, they some dayes after keeping at those Barnes a Guard of Horse and Foot relieved each night at nine.

November 1.—Our slender stock of Bread and Corne, that of Beere being spent, invites the sending forth Lieutenant Colonell Peake with Horse and Foot, to try what yet could more be done at Piats Hill, where comming about eight at night, finding their Fires, but their guards gone off; taking two prisoners begin their work, loading their carts, and sending them away continuing so till 12, what time their Horse from Sherfield comming down the hill and Foot from Basing drawing up, fall on our Guards, and for some time dispute it, but our Foot from the lyned hedges having gauled their Horse, give way to ours to draw theirs farther off, whilest their Foot acquainted with the ground strive to possesse the hedges some of ours maintained, but an Alarum from the Castle given upon the Church, and our Horse now freed of theirs, cause them retreate, driving them through the River, they thus beat off, we to our Worke again, and by the morning carry in 16 loads in sheafe, our Drovers at same time passed through our Guards eight Beasts, at noon next day some Souldiers stepping out seize on 12 sides of mutton and some pork loaded upon a horse as contribution food, going unto the Church.

November 5.—Our Beere being now spent, the Officers content themselves with water, having for ten dayes past spared one meale a day, and now perswade the Souldiers who as yet had two, this causeth one at night to run away, telling our wants unto our enemies, now animating them, before dishartened, had not the comming in of Strowd's and Ludlowe's horse with some Dragoones fastened their Leaguer, almost on remove.

November 6.—Coronet Bryan with a party of Horse using the benefit of a fogge, getting into the Bottome neere to Basingstoake, steales off three Sentryes, and placing there his owne, after a while without the noise of Pistoll, takes a Corporall and two Troopers more comming to their reliefe. This was a welcome to Strowde's new-come Horse. At night Major Cuffand with horse and Foot killing a Sentinell. and beating off their Horse, cleereth the passe to Piats Hill, and sendeth forth our men for Beasts, but the enemies' Horse that night too much abroad, make void this Journey; two run to them, one of them with a horse.

November 9.—The like party sent out at night under Command of Major Rosewell beating their Foot from a worke throwne upon the passe at the Delve (their Horse not daring come too neer the hedges) possesse the Avenues to Piats Hill, then sending forth our Graziers, who in foure houres time returne with eighteen Beasts, our Guards in meane while from the Barnes thereby passing six Load of Corne in sheaffe and securing two Messengers onward to Oxford, one sent three nights before being taken by the enemy.

November 13.—Colonell Ludlowe's Trumpiter is taken upon Cowdrey's downe, next day a Regiment of Foot shewing themselves at Chinham, marche to Basingstoake; and the morrow a Trumpet from Sir William for his Coronet is return'd with naming an Exchange; another bringing in two Officers of ours that long had lyen at Farnham, for them carryes out seaven of theirs, wee taking care to fill their roomes againe, within two houres after fetch in one and kill two more abroad. Their Army now again hovering about, afford us sport, each day killing or taking some of their curious ones. And seaze two carts, one with a Load of Hay passing too neere our workes.

The enemy wearied with Lying 24 weeks, diseases, with the Winter seazing them, his Army wasted from 2000 to 700, fearing the forces of His Majesty now moving about Hungerford, raiseth his Leaguer, and at eight this morne* drew off his Waggons and two Gunnes, three dayes before brought in. The Foot at noone march toward Odgiham, the huts being fired, and some Troopes of Horse left to secure their reere. On whom a party of our Horse with Coronet Bryan waiting their opportunityes disorder their retreat.

Next night† honoured Sir Henry Gage (the enemies remove not known) sent by His Majesty with 1000 Horse brings in supplies of Ammunition and Provision, each trooper in a bag bearing his part having a skeene of Match swadled about his wast, besides what

* *i.e.*, the 18th November, see following note.

† Gage was sent by the King from Hungerford on Tuesday the 19th ("Symonds Diary," p. 153; "Walker's Historical Discourses," p. 120). He would get to Basing the same evening. The King waited for his return at Farringdon, where he halted all the 22nd, and on the 23rd, leaving the Army at Farringdon, returned to Oxford. See Symonds and Walker as above quoted.

brought in Carts, and staying here three dayes most amply victualled the Garrison (drawn down by length of Siege, almost unto the worst of all necessityes, Provision lowe, the souldiers spent and naked, and the numbers few, having besides our hurt and maimed, and such as runne from us, lost neere 100 men by sicknesse, and the siege, whereof a Lieutenant-Colonell, two Ensignes, three Sergeants, and seaven Corporals.

I shall end all with these observations, viz. : That seldome hath been a seige wherein the preservation of the place more imediately might be imputed to the hand of God. That the souldiers in so long a seige with all the sufferings incident thereto, should never mutiny ; Nor that that (*sic.*) the customary Liberty at all our Parlyes for to meet and talke wrought any treachery, Wants of Provisions alwayes so supplied as if by miracle, during the Leaguer ; we not having lesse than seavenscore uselesse mouthes, that had reliefe come at the time appointed, Waller then hovering with his force at Farnham, in probability a hazard whether they had releived us, or preserved themselves. Or had Norton (able to bring three times their numbers forth) when the next weeke they came, drawne out his strength or had wee not got Powder from them, that by our releife scarce serving till the seige was raised ; or when we were relieved, had they not suffered us to possesse the Towne a weeke, thereout supplying ourselves for horse and man, before not having for above three weekes. Or had they when we first fetcht Corne from Piats Hill, or fired or removed it.

But God that holdeth all things in his hand, appointing times and seasons, ordereth all that tends unto those ends he wils ; in vain it therfore were to villify the enemy ; blaming his valor or discretion, or yet to say the care and diligence of the Lord Marquise Governour, the skill and valour of the Officers, the courage and obedience of the souldiers (though all these did their parts) had thus preserved the place, in vain we watch and ward, except God keepe the House. Let no man therefore speake himselfe an instrument, onely in giving thankes that God had made him so, for here was evidently seen *He chose the weake to confound the strong*, *Non Nobis Domine*, Not unto us, not unto us O Lord, but to thine owne name be all glory for ever, Amen.

APPENDIX D.

A Diary of the Siege of Colchester by the Forces under the Command of General Fairfax.*

Tuesday, June 13.—The Lord Fairfax engaged in the fields before Colchester, near St. Mary's, the Lord Goring's Forces, together with the Forces under command of the Lord Capell and Sir Charles Lucas, and beat them into the Town; Colonel Sir William Leyton and between 400 and 500 of the King's Forces were taken prisoners (200 of them being Col. Farr's Regiment) and in pursuit of the rest, Col. Barkstead with his Regiment, entered the suburbs as far as the Head-gate, and entered the gate, but being overpowered there, and driven out of the churchyard, the King's Forces barricaded the gate leaving near 500 men to our mercy; yet, notwithstanding, those foot and Col. Needham's fought many hours after in hopes to gain the town at that place, but could not, the King's Forces making good resistance. There were slain of the King's Forces, Colonel Sir William Compton, Col. Cooke, and divers officers of quality, and about 80 private soldiers; Col. Panton, Capt. Brunkerd, Clifford, Worsop, and divers other officers wounded. On General Fairfax's side Col. Needham, Capt. Lawrence, of Horse, and Capt. Cox, of Foot, and near 100 private soldiers and inferior officers were slain. When we entered the suburbs the Lord Goring was summoned, but returned an answer not becoming a gentleman.† The word of the King's Forces at the Fight was *Charles*; the ground they fought upon, *Mary's*; ours, *God's our help.*

* This Diary is printed on the broadsheet which contains the plan of the attack, a reduction of which is given in Plate XIV. The broadside is in British Museum Catalogue ascribed to the year 1650. Thomas Witham printed and sold it at the Golden Ball in Long Lane, near West Smithfield, London.

† The answer referred to appears to have been to the effect that having heard Fairfax was suffering from gout "Goring would cure him of all diseases."

The Forces under the command of General Fairfax engaged in the fight before Colchester, June 13, 1648; as also the names of the Chief Commanders and persons of quality of the Lord Goring's Forces engaged at that Fight.

General Fairfax's Forces engaged in that fight. Part of the General's Regiment of Horse being four troops, commanded by Major Desborough.

Of Colonel Whaley's Regiment, six troops, commanded by himself.

Of Colonel Fleetwood's, five troops, commanded by Major Coleman.

The troops of Commissary General Ireton's, commanded by Capt. Cecill.

The troops of Dragoons, commanded by Capt. Freeman and Capt. Barrington.

Of Foot.

Colonel Barkstead's Regiment, commanded by himself, consisting of ten Companies, about 800 men.

Colonel Needham's Regiment, lately the Tower Regiment, commanded by Col. Needham, being seven Companies and about 400 men.

Part of Colonel Inglesby's Regiment of four Companies, commanded by Capt. Grimes, 320 men.

Of the Essex Forces.

Colonel Harlackenden's Regiment of four troops of Horse, commanded by Major Robert Sparrow, and Capt. Turner's troop of Dragoons.

Sir Thomas Hunniwood's Regiment of Foot, Colonel Cook's Regiment of Foot, both which said Regiments consisted of auxiliaries and trained bands.

The County Forces of Essex left to secure Chelmsford and Malden, two considerable passes, lest more Forces should resort from London to the Lord Goring.

Colonel Henry Mildmaies' Regiment of Horse and two troups of Dragoons.

Part of Colonel Mildmaies' Regiment of Foot, commanded by Major Bard.

The Suffolk Forces, who made good the passes over the river at

Nailand, Stratford, and Cattaway, lest the enemy should scape towards Suffolk and Norfolk, were under the command of Capt. Fisher, Capt. Bradley, and Capt. Sparrow, besides the assistance which Capt. Ball, Capt. Cox, and the rest of the Sea Commanders gave to secure the river.

The Suffolk Forces that came afterwards to help to besiege this Town.

Colonel Gourdon's Regiment of Horse.

Of Foot Regiments—Colonel Sir Thomas Barnardiston's, Colonel Fothergil's, Colonel Harvey's, Colonel Bloise's.

Of the Army that came up after the Fight—Colonel Scroop with three troops of Horse of his Regiment.

The Lord Goring's Forces engaged in that Fight.

Of Horse.

Lord Goring's Regiment, Lord Capel's, Sir William Compton's, Colonel Slingsbie's, Colonel Bernard Gascoigne's, Colonel Hamond's, Colonel Calpepper's.

Of Foot.

Sir Charles Lucas, his Regiment, Sir George Lisle's, Colonel Tilley's, Colonel Tewk's, Colonel Farr's, Colonel Gilburd's, Colonel Sir William Campion's (himself slain), Colonel Burd's, Colonel Bowman's, Colonel Chester's.

Colonels who had no command of Regiments, yet assisting at that Fight.

Earl Louborough, Lord Hastings, Sir William Leyton, Colonel, taken prisoner and wounded, Colonel Sir Richard Hastings, Colonel John Heath, Colonel Lee, of Kent, Colonel Panton, wounded, Colonel Cook, slain, Colonel Sir Hugh Orelie, Quartermaster Gen.; Colonel William Maxey, Colonel Pitman, Colonel Beal, Lieut.-Col. Hatch, slain, Major Jammot, Adjutant Gen.; besides divers Lieutenant-Colonels and Majors who were assistants but had no command.

Wednesday, 14.—General Fairfax perceiving that Lord Goring's Forces would not stand the field, resolved to sit down before the Town in order to a siege, but being too few to storm it, having not then, nor when he engaged, 1,500 old Foot, and but about 1,500 Horse, and two troops of Dragoons besides the two Regiments of the Trained Band under Colonel Sir Thomas Hunniwood and Colonel Cooke, the Lord Goring's Forces at that time being about 6,000

Horse and Foot in Town, and the Town and suburbs larger in compass than Oxford, and would require 5,000 men to besiege it, appointed Lexden, in the road to London, for the Head Quarters, where the greatest body was to lie to prevent more aid coming from London to the Lord Goring, and kept strong guards of Horse on Cambridge road, on the other side of the river that they might not escape Northward to join Sir Marmaduke Langdale, leaving no place open to them but towards the sea where they could not go far; and the same day our General sent a party of Horse to secure Mersey Island to prevent the King's ships from coming into the river to relieve the Town; the Besieged sent Col. Tuke with a strong party an hour after but came too late.

Thursday, 15.—The Besieged's cannon from the Royal Fort at St. Mary's played very hard, killed several of our men as they did the day before, some as they were raising the first work, called Fort Essex, others as they were stragling to the field.

Friday, 16.—Nothing of importance happened, but three of Capt. Canon's men killed with a cannon bullet.

Saturday, 17.—A Trumpet sent in about the exchange of prisoners, and this day the Besieged got provisions out of Tendring Hundred, which we could not prevent till the Suffolk forces marched to our assistance.

Sunday, 18.—We took two of their Frigates, the one with ten and the other with eleven guns, and this day Colonel Hewers came up with six Companies from Chepstow Castle. The Essex Foot, under Sir Thomas Hunniwood and Colonel Cooke, endured many cannon shot this day, and were very ready upon an alarm.

Monday, 19.—The party of Horse sent from the Leaguer, under Major Sparrow and Capt. Wallingford, engaged the King's Forces at Linton coming to assist the Lord Goring, where Major Muschampe and others of the King's Forces were slain, and Major Reynolds and others taken prisoners, the rest, about 500, dispersed. This day a Trumpet came from the Lord Goring pretending to desire a treaty of Peace.

Tuesday, 20.—Answer returned, if a general Peace was intended that then it was proper for the Parliament to determine of that, and offered them in that answer conditions, viz., the Gentlemen and Officers to go beyond the sea, and the soldiers to go home without prejudice.

Wednesday, 21.—The Besieged returned a scornful answer, moving for a free trade for the townsmen.

Thursday, 22.—A small party of the Besieged sallied out to view a new work, afterwards called Col. Ewer's Fort, but were instantly beaten in by Musquetiers. Their cannon killed two men of ours. That day the Lord Goring sent a summons to the Suffolk Forces at Cattaway Bridge, commanded by Capt. Fisher and Capt. Brandling, to join with them, which they refused resolving still to adhere to the Parliament and Army.

Friday, 23.—The guns begin this day to play from our new battery, which much annoyed the Besieged at North-bridge. Our General sent a reply concerning his former offer, offering the same conditions again to all in the Town, except the Lord Goring, Lord Capel, and Sir Charles Lucas.

Saturday, 24.—One of the Besieged's cannoneers was killed. This day the Suffolk Forces advanced out of their own County and took up their Quarters upon Mile-end, over against the North-gate, being about 2,500 Horse and Foot, leaving a guard at Cattaway and Nayland to secure those passes.

Sunday, 25.—Nothing of importance.

Monday, 26.—A party of Col Barkstead's Foot (the Besieged having drawn out near the Alms-house) beat them from the Hedges, and from their court of guard, fired the guard house, and brought away the hour-glass by which they stood centry.

Tuesday, 27.—A Trumpeter went in with the Lady Campion's servant, with a letter to her husband, for she did not believe he was slain.

Wednesday, 28.—Chewed and Poysoned Bullets taken from several of the Besieged. Affidavit made by those soldiers of the Besieged who brought them out of Colchester, that they were given out by the Lord Goring's special command. These examinations were sent to the Lord Goring with this message from our General—that his men should expect no Quarter hereafter if they used such Bullets. This day, early in the morning, the Besieged with a party of Horse very boldly attempted our Horse Guards, near St. Mary's, shot a scout, but were instantly beaten back.

Thursday, 29.—They killed some Horse and Foot of ours with their great cannon, as they shot against our men at the making of Col. Barkstead's Fort, fired the house which was lately Sir Harbottle Grimston's, and at night fired Mr. Barrington's house ; a party of the Besieged's Horse advanced over the Bridge at East-gate, where ambuscades being laid for them by our Dragoons, Lieut.-Col. Hatcher, and divers other Officers and soldiers of the Besieged, upon their hasty advance, were slain ; none on our part.

Friday, 30.—Exchange offered for Sir William Massam, but refused.

Saturday, July 1.—Col. Whaley possest Grinsted Church.

Sunday, July 2.—Strong guards kept that night to prevent the Besieged's escape Northwards, we having notice of their intention.

Monday, 3 *and Tuesday*, 4.—Little of moment happened, except a Porter or Chamberlain coming from the Bell in Gracechurch Street, stole into the Town with intelligence of the Earl of Holland's raising an Army in and about London for their relief.

Wednesday, 5.—The Besieged sallied out with a strong party commanded by Sir George Lisle, surprised our Guard at East-bridge, and gained two Drakes, but advancing to the main guard, were routed by Col. Whaley's Horse, commanded by Major Swallow; 19 slain on the place, the Drakes recovered, and our former ground also; Lieut.-Col. Weston, Lieut.-Col. Weeks, and 80 odd Prisoners were taken, most of them sore cut for shooting poysoned bullets (20 of them died the next day). On our part, we had slain Lieut.-Col. Shambrooke and some others of Col. Needham's Regiment, who were engaged. Capt. Moody on our side wounded and taken prisoner, and one Lieutenant and Ensign and 40 private soldiers of ours taken prisoners also.

Friday, 7.—Col. Scroop sent from the Leaguer by our General with a Regiment of Horse to engage the Forces under the Duke of Buckingham and Earl of Holland, got into a body to raise the Siege.

Saturday, 8.—News of Col. Rossiter's routing the Pontefract Forces at Willoughby field, where three troops of the Army were engaged, and many of the men wounded; Col.-General Sir Philip Mouncton, Major-General Biron, and divers Officers of quality taken prisoners by Col. Rossiter.

Sunday, 9.—News of the Earl of Holland and Duke of Buckingham's being routed in Surrey, and of the Lord Villiers being slain by Sir Michael Levesey and Major Gibbons, who commanded a party of Horse of the Army.

Monday, 10.—Several of the Besieged came away to us. News came this day of the taking of 600 Horse in Northumberland, and of Sir Francis Ratcliff, Col. Tempest, Col. Grey, and other prisoners taken by Col. Lilburn.

Tuesday, 11.—We had a Gunner and a Matrose shot as they were battering St. Mary's steeple. News came this Day of the Earl of Holland's being taken prisoner by Col. Scroop, and Sir Gilbert Gerrard and others of quality, and that Col. Dalbeer was slain, and their whole force dispersed at St. Neots, in Huntingdonshire.

The 12 *and* 13.—Little of moment happened, only Mr. John Ashburnham offered in exchange for Sir William Massam, but not accepted: and this day the messenger who came to our General with a letter of the taking of Waymer (Walmer ?) Castle in Kent, took his opportunity and carried it into Colchester to the Lord Goring, and took up arms there.

Friday, 14.—The new Battery being raised against St. John's from the Lord Lucas's house, two pieces of cannon played thence, made a breach in the wall. The Soldiers entered, fell on immediately, drove the Besieged out of the first court-yard into the second, and thence into the gate-house, and the same day a strong party of Horse and Foot fell upon the Hyth, and stormed the church, and took all the guard therein prisoners, being about 70, and that night we possest ourselves of the Hyth and a great part of the Suburbs, which much troubled the Besieged. The Suffolk Foot did well in this service.

Saturday, 15.—The Gate-house being a place very considerable and mighty advantageous for us, our General resolved to storm the same, though it had a strong work before it, whereupon six soldiers for 3 shillings apiece undertook to throw in grenadoes, and 20 men to carry ladders for half-a-crown apiece and a commanded party of Foot to storm led on by Major Bescoe which accordingly they did as soon as 8 pieces of Cannon had given fire upon the besieged and the granadoes did great execution the ladders were placed at much advantage the Besieged much dismayed forced to quit their works and fly into the gate-house; one grenadoe kindled their magazine and blew up many of the besieged the rest were taken prisoners and slain; the prisoners confest they were above a hundred in the gate-house and work and few of them could escape; 13 at one place were pulled out the next day from under the rubbish. This night the Besieged endeavoured to escape with their Horse commanded by Sir Bernard Gascoigne and past the river between the North bridge and Middle-mill and had the miller for their guide, but the miller when he came into the closes ran away and the Pioneers after him, and our centinels giving fire the Besieged retreated. The suburbs were fired in 6 or 7 places which burnt in a most dreadful manner all night long, that the town might be seen almost as well by night as by day so great was the flame. And on Sunday the 16 other streets were set on fire with design to consume the whole suburbs, but by the industry of the inhabitants and soldiers it was prevented. This day our General had certain intelligence that an Army of Scots under Duke Hamilton had invaded the kingdom and joined the Cavaliers under Langdale.

Sunday, 16.—Our General sent a summons again to surrender the Town. The Lord Goring, Lord Capell and Sir Charles Lucas jointly returned answer in writing under their hands to our General, that if the Trumpeter came any more with such a summons they would hang him up. The conditions then offered to the soldiers were Liberty and Passes to go to their several homes submitting to the authority of Parliament.

Monday, 17.—Again more houses were fired towards the North-street and other places. This day our General had certain news brought him of the surrender of Pembroke town and Castle, Langhorn and Poyer submitting their lives to mercy.

Tuesday, 18.—Their Horse again attempted to break through towards the North but were beaten in again.

Wednesday, 19.—Seventeen of the besieged this day came over to us and their Horses were all drawn this day into the Castle yard and a certain number out of every troop was chosen to be killed, and there were told in the Castle bailey 700 Horse belonging to the soldiers.

Thursday, 20.—They killed their horses; one Butcher ran away rather than he would do it. The Besieged at night drew out their Horse at 12 of the clock and afterwards at 2 of the clock in the morning to escape, but our men were in such readiness they durst not advance.

Friday, 21.—News came of Capt. Batten's revolt to the revolted ships, deserting the Parliament and turning to the King.

Saturday, 22.—Several soldiers ran from the besieged much complaining of their diet in horseflesh and a Trumpeter was this day sent again to expedite the exchange of Sir William Massam for Mr Ashburnham, but the besieged refused it as also to admit of the exchange of the rest of the committee though they had gentlemen of very good rank offered for them quality for quality in exchange.

Sunday, 23.—The besieged roasted a horse near the North bridge to make the soldiers merry at the entrance with such diet; this day our General had intelligence of Col. Lambert's engagement with the Scots near Appleby where above 200 Scots were slain Col. Harrison and others on our part wounded.

Monday, 24.—Nothing of moment.

Tuesday, 25.—The Besieged had a hot alarm round the town about 12 at night and a party in the meantime fired the middle mill with the loss of 3 men and cut off a sluice, but the fire did not take so the design proved ineffectual at that time; at the same time we shot 20 arrows with papers of advertisement affixed into the town to undeceive the soldiers acquainting them with what conditions were offered them and shall still be made good unto them if they come out which coming to some of their knowledge above 200 come out by that day seven night.

Wednesday, 26.—Nothing of moment.

Thursday, 27.—A troop of Lord Capell's sallied out and took 3 or 4 men as they were working upon the line near St. Botolph's and wounded 1 miserably being a country soldier and but a spectator.

Friday, Saturday, and Sunday, 28, 29, and 30.—Nothing of moment.

Monday, 31.—In the night about 20 of them with spades 6 only having muskets past the first centinel as friends saying they were come to make an end of the Work where they wrought the night before, but were fired upon by the second guard, had a lieutenant slain and retreated and took a Sergeant with them prisoner.

Tuesday, August 1.—A Cornet, Quartermaster, Corporal and 1 Trooper came away with their horses.

Wednesday, 2, *and Thursday*, 3.—There came several soldiers from the besieged much complaining of their ill diet with horseflesh and said it was attended with gentlewomen in white gowns and black hoods (meaning maggots) so that they could not eat it and that it had brought many of them to the Flux.

Monday, 7.—Nothing of moment happened. This day it was resolved at a full Council of War to proceed by way of Approaches in order to a Storm.

Friday, 11.—Nothing of note. This night 30 houses were burnt.

Tuesday, 15.—Many men came over this day from the besieged and the poorer sort of people began to rise for want of bread.

Wednesday, 16.—They rose in great number and came to the Lord Goring's Quarters, some bringing their children starved to death, they crying out as long as Horseflesh, dogs and cats were to be had they did not complain. This day the Mayor of Colchester sent a letter to the General that the inhabitants might come out for that they had no provision, it being all seized by the Soldiers. Our General returned answer he pitied their condition but to grant that was to make the Town hold out longer and did not stand with his trust to permit it. This day we had the news of the killing and dispersing of the Prince's Forces by some Horse and Foot of the

Army commanded by Col. Rich, near Deale, and also of the regaining of Tinmouth Castle by Sir Arthur Haselrig.

Thursday, 17.—The Lord Goring, Lord Capell, and Sir Charles Lucas, who before threatened to hang our Trumpeter if he came any more with a message for a Parly desired our General they might send to the King's Forces and if they had not relief within 20 days they would then treat. Answer was returned by our General that he hop'd in much less time than 20 days to have the Town without Treaty. All things are preparing in order for a storm.

Friday, 18.—No action but preparation for storm.

Saturday, 19.—The Besieged sent for a treaty to surrender.

Sunday, 20.—The General returned an answer to their offer for a Treaty, that all Soldiers and Officers under the degree of a Captain, excepting such as have deserted the Army since the 10 of May last, shall have Passes to go to their several homes ; and all Captains and Superior Officers with Lords and Gentlemen to mercy.

Monday, 21.—The Besieged turned out of the town in the night many men women and children but the next morning took them in again.

Tuesday, 22.—The Besieged sent out Major Sheffield one of the committee that was prisoner in Colchester that they would surrender upon honourable conditions and desired to know the meaning of the word mercy. This day the news of routing the Scotch army came which we sent into the Town.

The journal ends here on the broad sheet, but the town was not held much longer. On the 25th some intention of cutting their way out through the enemy was considered by the besieged, but the spirit of the troops was not in favour of this procedure. On the 27th August articles were agreed to and signed, and the following day the town was rendered. A council of war was held on the same day, and as a result of its deliberations Sir Charles Lucas and Sir George Lisle were shot the same evening on the North side of the Castle. Fairfax has been much blamed for this act of severity ; to discuss the matter here would take too large a space ; it may be asserted, however, that there is a good deal to be said on both sides of the question.

References to the Plates.

No. I.—Plate of Siege Details.

The figures represent various details, taken from contemporary technical orks already specified in the text.

No. II.—Kingston-on-Hull.

Showing the town walls, and castles or blockhouses, as they existed immediately before the Civil War. The plate is taken from a plan by Hollar, dated 1640; this plan has been reproduced in Tickell's "History of Hull." The works built during the War, in addition to the old walls, are mentioned in the contemporary literature of the War, but so far as is known no plan of them exists.

No. III.—Portsmouth.

This plan is a reproduction of one contained in a collection in the British Museum (Add. MSS. 16370), which appears to have once belonged to Sir Bernard de Gomme, chief engineer of England under Charles II. This plan appears to be the result of a survey, by one M. la Favelure, of the then existing defences of the town, made probably for the guidance of De Gomme in his project for remodelling the fortifications. It is probable that the works here represented include the old enciente of Henry VIII. and Elizabeth's time, as well as the works, to carry out which Rudd was sent down shortly before the beginning of the Civil War.

This collection of plans and documents (Add. MSS. 16370 and 16371) were purchased by the British Museum at the sale of the library of Mr. Gwyn, of Ford Abbey, Dorsetshire, in 1846, and is believed to have come in the possession of this family through Francis Gwyn, who was Under-Secretary in 1680–2; see the account of the matter by Sir Frederic Madden in the *Illustrated London News* of 5th January, 1856.

No. IV.—Reading.

The original of this plan is on vellum, and is to be seen in the British Museum in the Add. MSS. 5415. The name of the draughtsman is not mentioned, and is unknown.

In the Museum catalogue the scale, stated to be one of 380 feet to the inch, is incorrectly entered. The error appears mainly due to a slip of the pen on the part of the draughtsman. For on the plan the "rod" is stated to be 10 feet, whereas it was, in contemporary technical works, invariably taken at 12 feet. The error was discovered by comparing a known distance on the ground with the corresponding dimension in the drawing; when it at once became apparent that, were the rod taken at 12 feet, the plan of the fortifications would be in harmony with the facts on the ground; with the rod assumed as only 10 feet, the plan gave very inaccurate results. But, in any case, the catalogue is incorrect, for, assuming the rod to be 10 feet only, the resulting scale should have been stated as a scale of 370 feet to the inch. With the rod at 12 feet the scale of the original drawing becomes 444 feet to the inch, or almost exactly 12 inches to the mile.

No. V.—Bristol.

This plan is a compilation from various sources. The principal authoritie for the works shown on it have been :—

1. A large plan of the city, "surveyed and drawn" by John Rocque, and engraved by John Pine in 1742. A remark on the plan states that the city, at the time the survey was made, was "near one-third larger than it was forty years ago." Rocque's plan, on a reduced scale and with some additional roads, etc., is accurately reproduced in Barrett's "History of Bristol."

2. A plan of the city and forts, said to be by a contemporary of the time of the Civil War, and reproduced in "Archæologia," vol. xiv. The limits of the city are taken here from the Archæologia plan.

3. Millard's plan of the city, stated to be of the year 1670 or 1672. Among other illustrative matter, printed on the margin of this plan, is a plan of the Fort Royal, showing it to have been a pentagon. Barrett and Seyer both reproduce this fort plan, the latter somewhat inaccurately.

4. The account of the defences ascribed to de Gomme, and given by Warburton *in extenso* in "Memoirs of Prince Rupert," vol. ii.

5. De Gomme's narrative and report on the defences, as they stood at the time of the second siege (1645), given in a pamphlet called Rupert's "Declaration" (Thomason Collection, E. 308. 32), and reprinted in Warburton, vol. iii.

6. Slingsby's account of the assault in 1643, to be found among the Clarendon MSS., Bodleian Library.

Other contemporary accounts have also been consulted, and the notices of the fortifications occurring in Barrett's "History," and Seyer's "Memoirs of the City," as well as in later works, have been considered in drawing up the present plan.

No. VI.—London.

The plan shows the fortifications thrown up round London during 1642 and 1643.

The table of reference is given from Vertue's print, or, to be more accurate, from the reproduction of it in Maitland's "History of London."

The original drawing, from which Vertue, in 1738, published his print, is, in the catalogue of the MS. maps in the British Museum, stated to be "copyed from Wenceslaus Hollar's map of England in six sheets, and traced from the remains and footsteps of the works by Cromwell Mortimer, M.D., Secretary of the Royal Society."

In a late history of London it is stated ("History of London," W. J. Loftie, 1883, I. 345), that at Hackney some remains of works might still be seen "not long ago." The work at Tyburn Road (No. 13 in list) was close to what is now Rathbone Place. No. 11 may possibly be still commemorated in Castle Street. On the West a large earthwork long known as "Oliver's Mount" is now represented by Mount Street, Grosvenor Square.

These fortifications were partially dismantled by the Army in 1648.

No. VII.—Oxford.

This plan of the fortifications thrown up round Oxford during the Civil War is reduced from a plan given in the "History of Oxford," by Anthony à Wood, 1674. A work written in Latin.

In 1796 a translation of this work appeared, by John Gutch. In vol. II. is given a description of the works. The rivers Isis on the West, and Cherwell on the East, were so ordered that the city could be surrounded with water, except on the north part of it, at the pleasure of the defendants. On the north side the ground was "indifferently high," and was provided with a series of strong "Bulworks" of regular trace. "Storm poles" were fixed both on the bulwarks and the curtains, and palisades were fixed upon the outside of the ditch. Without them again were "digged several pits in the ground that a single footman could not without difficulty approach the brink of the trench."

The design is supposed, on good authority, to be by one Rallingson, a scholar of the University. See the question discussed under the head of the Defence.

No. VIII.—Plymouth.

This plan is copied from a print by Hollar, which is given as an illustration to the account of the famous siege endured by this place in the end of 1643. This pamphlet, of which there is a copy in the British Museum, among the tracts collected by the industrious contemporary Thomason (see vol. 141, small 4to., indexed E 31. 15), is of extreme rarity, and the following is its full title :—"A True Narration of the most Observable Passages in, and at, the Seige of Plymouth, from the fifteenth day of September, 1643, until the twenty-first of December following. Attested from thence under the hands of the most credible Persons : Wherein is manifasted to the World the handy-work of God, and his gracious assistance to the united Forces of that Towne and Garrison. Together with an exact Map and Description of the Town and Fortifications thereof ; with the approaches of the Enemie. As also the Summons of the Cavaliers to the Mayor and Governour of the said Towne, and Prince Maurice his Warrant to the Countrey since the raising of the Seige. *Imprimatur* John White. London. Printed by L. N. for Francis Eglesfield, and are to be sold at the signe of the Marygold in Paul's Church-yard, 1644."

On the copy in the Thomason Collection there is an entry, in Thomason's handwriting, to show that it was published on the 5th of February, 1643-4.

The map is by Hollar, and the copy now made is a close reproduction of it, although not absolutely a facsimile.

No. IX.—Liverpool.

This plan shows the fortification of Liverpool as originally executed when occupied by the Parliament. The design for its re-fortification by Bernard de Gomme is also shown, being taken from a plan by that officer among other papers in the Sloan MSS. in the British Museum. The index number of the original plan is 5027, A. 63.

The work seems to have been not entirely completed. The ditches are shown in blue, but possibly this colouring may have only been conventional. The roads are as shown, shaded on one side, but whether this was intended to convey that they were below soil, or were provided with parapets, does not clearly appear.

No. X.—Newark.

The full title of the original is "A Description of the Seidge of Newarke upon Trent, with the fortifications about the Towne, as also the forme of all the Entrenchments, Forts, Redouts, Batteries and Approches, made against it under the conduct of the Earl of Leven, Capt.-Genl. of the Scots Army, and Coll.-Genl. Pointz, and Coll. Rosseter, comanders in chiefe of ye English forces; it begun ye 6th of March, 1645 (*i.e.*, 1646), and ended ye 8th of May, 1646."

No. XI.—Worcester.

From a print in the British Museum.

In addition to the references given on Plate, various shields of arms are also on the print, and the site of the battle of Worcester, or of some fighting, is also represented on it very much out of scale. These features of the original have not been reproduced.

No. XII.—Donnington Castle.

From a plan in Grose's "Antiquities of England," vol. i. It has been frequently reproduced in local histories, etc. The original survey was made by an officer in 1768, and the accuracy of the plan is mentioned by Grose. For this reason, as probably representing the condition of the works, before much more than a century had elapsed since their construction, this plan is given, although, as examined now on the ground, the trace of the ramparts is not so definite as would appear by the plan to have been the case 120 years ago.

No. XIII.—Basing House.

Plan reduced from the ordnance survey map to illustrate the journal of the siege given in the Appendix (C). The works shown on the ordnance map have been personally inspected, and are accurately shown on that map.

No. XIV.—Colchester.

From a contemporary broadside (not to scale) with title "The Siege of Colchester, By the Lord Fairfax, as it was with the line and outworks, 1648."

The camping positions of the troops are shown in original, but, with other unimportant matter, are omitted in this copy.

No. XV.—Tilbury Fort.

Plan and section showing one of the designs of Sir Bernard de Gomme for the improvement of the old blockhouse at Tilbury. The designs are some three or four in number, and the work appears to have been carried out on a pentagonal exterior side; one of the angles of the pentagon being turned to the river. The designs are expressly stated to have been made by "Sir Ber. de Gomme, Kt., Chief Engineer" in Oct. 1670, and also in 1668. They are to be seen, with estimates, etc., in Add. MSS. 16370, an account of the acquisition of which, by the British Museum, has been given under the heading of No. III. (Portsmouth) Plate reference.

PAPER V.

GEOGRAPHICAL SURVEYING.

By Lieut.-Col. T. H. Holdich, R.E.

Triangulation.

The development of all branches of military science in these days has brought with it a corresponding demand for improvement in our processes of military surveying, and for better systems of supplying ourselves with such geographical information as is necessary to assist our military and political leaders to decisive and prompt action in the field. Promptness and rapidity of action are more than ever the fundamental basis of success, and the principle applies as much to surveying as to any other branch of military science. The demand for geographical information, by which alone decisive action can be insured, is met, as regards the civilized and already mapped portions of the world, by an elaborate system of "intelligence" which utilizes published maps, and continually adds fresh information of a military and statistical character to its store of knowledge. But the intelligence department is rather a map collecting and map compiling than a map making department, and the demand for new geography falls on those departments that make surveying a speciality both at home and abroad. So far as I know, there is no organised body of geographical surveyors in England, nor is it, perhaps, very urgently necessary that there should be. In India, on the other hand, there is a staff of military geographers, but it cannot be said to possess any definite organisation at present. It is, however, not with the question of organisation that I wish to deal, but with the Indian system of surveying, and here we may be justified in claiming a certain amount of success, although we have yet much to learn, and know ourselves to be very far from perfect in the art.

Taking India as our practical centre of interest in the East, there is in India a most urgent necessity for all that class of information which may be comprehended under the general term of scientific geography. I am not now referring to India only, or to the frontiers of India and the countries lying close to our borders. India is, as I say, the centre of English interest in the East; but that interest extends itself far and wide—to China, Thibet, and Japan on the one side, to Persia, Arabia, and Africa on the other. I include Africa, because I think (although I cannot pursue the question further here) that the geographical knowledge that we require about African regions generally would be better secured by means of Indian agency than by European. Looking at the map of the world, we cannot say that any probable theatre of future British military operations in uncivilized and unmapped regions, such as require good square military maps as guides to rapid and successful action, lies beyond the reach of Indian surveyors, but these surveyors must be taught and led by English officers, chiefly by officers of the Royal Engineers. Nor, whilst regarding the paramount importance of clear geographical knowledge to a General in the field who wants a clear plan of action before him, must we forget the great civil interests which sometimes lie hid between the unopened geographical pages of the great book of the world. About the regions with which our military interests are most closely connected I will say nothing, except that we have only begun as yet to know something about them. Do not imagine for an instant that our geographical record is complete, or that it can possibly be so for many years to come. On the other hand, our civil interests extend over all the world of trade, where railways and road connections yet have to be made. Civilization in the East is as old as the Eastern hills, and yet it is young, and in the great see-saw of the world's progress it is now developing again from the West, chiefly through the agency of English engineers, both military and civil. You will have to take your part, some of you, in unravelling the knotty questions of communication between India and the further East of China; or, may be, in completing that long-talked-of iron link between Europe and India, which will do more to establish peace and good-will between West and East than reams of protocols, agreements, and treaties. I am not indulging in any sentiment. International peace and good-will depend on national self-interest, and national interest is largely concerned in railways and trade routes.

Premising, then, that this matter of geographical surveying is one which must inevitably interest many of you, I will try as clearly as I can, first, to explain what I mean by geographical surveying, and then to show the means which have been lately adopted in India to carry it out successfully. Geographical surveying is to military topography, very much what strategy is to tactics. In your military topographical maps, reconnaissances, and sketches, you aim at giving detailed information of such sort as may facilitate the movement of troops, or the conduct of an action, as fully as you possibly can, whilst subordinating all those minor features and details which have no practical military bearing. Extend this idea from the representation of a few miles of road, or a few thousand acres of country, to many thousands of square miles, and you still have the first principles of military geography. Your surveys and reconnaissance sketches should be, indeed, a part of geographical surveying, and the more facility you acquire in making them the better. But if you are to make your local surveys useful for geographical purposes, something more is required. Each sheet of topography is but a unit which has to take its proper place in the final geographical map, and unless the means of applying it to this end are clearly defined on the face of it, half of its value will be lost. You know as well as I can tell you that topographical detail must be based on some framework of exact dimensions; that is to say, you must triangulate first, and fill in topography afterwards. The English system is to carry out this triangulation by means of accurate azimuthal instruments, such as theodolites; to keep the record, compile the results, and plot the positions of points so fixed by their co-ordinate values; and it is on the basis of the points so fixed that all the subsequent topographical detail hangs together, and the general accuracy of the whole map is preserved.

The great object to be held in view in all military surveying is simplicity, and simplicity is best attained by the use of as few instruments as possible, and the reduction of all the various processes of map-making to the fewest possible number. It is for this reason that the plane-table has now been almost universally adopted for topographical work as an adjunct to the theodolite, in all cases where rapidity of execution is as much an object as accuracy in detail. In most countries, notably in America, Russia, Germany, and France, plane-tabling is generally applied to all survey purposes whatsoever. In England it has happily superseded some of the more complicated systems of building up a map by means of a succession of processes, such as observing with a prismatic compass, and then plotting with a protractor; but it has not yet taken its place in our ordnance surveys, and these still depend chiefly on chain measurements for detail work, and involve the necessity of repeatedly going over the same ground. All the countries I have mentioned have, more or less, extended the use of the plane-table to triangulating purposes. Doubtless there is a gain in simplicity by this extension of its use. If all the processes of completing a survey could be reduced to one single instrument, which is easily carried and not liable to damage with ordinary care, a very great advantage would undoubtedly be gained, and it appears to me that within certain limits of space and opportunity, and with the full use of such recognised adjuncts as definite marks or signals to which observations can be taken, and about the position of which no mistakes can arise, this extended use of the plane-table is certainly to be advocated. Given the possibility of obtaining a rigid instrument, constructed of material unaffected to any appreciable extent by atmospheric changes, with simple arrangements for levelling, and telescopic power attached to the sight rule or "alidade," and we have at once the power of measuring horizontal angles to within a few minutes of arc, and of determining an interpolated position to a degree of accuracy which is only limited by power of eyesight. More than this is hardly requisite for ordinary mapping over limited areas.

American surveyors, indeed, claim more than this; they say that with their elaborate plane-tables, points fixed by interpolation or by the intersection of rays at angles not very acute, are better fixed and preferable to those plotted by their co-ordinate values after computation; that is to say, that their system of graphic triangulation is superior over limited areas to instrumental triangulation combined with computation and subsequent plotting; and they argue that the more elaborate process of theodolite triangulation is also more costly and involves more time. This is a question which it may well be worth while to consider presently. I will only remark at present that graphic triangulation is largely resorted to by Russian geographers, who use plane-tables which, so far as I have seen, are constructed very much on the American principle.

But geographical surveying does not deal with limited areas, nor is it possible to ensure that time and opportunity will be available for any well considered and well balanced system of triangulation at all. Herein lies the difference between the geographical surveying that is constantly requisite to provide for the contingencies of military operations, and the more exact system of map-making, which can be carried on at leisure on a well-regulated plan of procedure. Geographical surveying may frequently be as irregular in its nature as it has been wide in the areas with which it has to deal. The great fundamental principles remain the same. We must have a framework of well fixed points on which to piece together all the varied units of topographical survey or reconnaissance, and it must be remembered that the wider the area, the more exact must be the framework in all its details. The topography may be of all degrees of finish and accuracy, from a rough reconnaissance carried out on horseback with the simplest form of sketching-board, to an elaborate and well-finished delineation of such country as may be the centre of special attention for military purposes. But from the rough reconnaissance to the finished topographical map, all must depend on the primary values of certain easily recognised and well determined points. Otherwise we shall never attain the great end of geographical mapping, a square map of a whole country, with all topographical detail relatively correct, however incomplete—entirely accurate as far as it goes, and serving its purpose of assisting our military and political leaders to a complete and comprehensive knowledge of the whole theatre of operations. Thus the one great problem to be dealt with throughout the conduct of a geographical survey, when that survey has to be carried out under military exigencies, is the problem of keeping one's exact position, in order to fix others exactly, as the survey progresses day by day. As I proceed to describe the various means that may be adopted in order to meet this difficulty, I think you will see that advantageous as would be the simple arrangement of dealing with one single instrument, we never could arrive at the results we have already attained by the use of the plane-table alone. Two great desiderata are unattainable by the plane-table, viz., a written record, and the power of taking astronomical observations; and you will probably admit that both are indispensable.

There are three very distinct classes of survey operations, all of which may fairly be termed geographical. The first military survey of any country is a geographical survey, by which I mean that it is not undertaken for fiscal purposes, and generally results in a map on a comparatively small scale, on which the purely geographical features are most apparent. Such surveys are conducted on regular principles which I need not enter into. Again, the first tracks made by explorers across any unknown region results usually in a map where nothing is represented but vague and uncertain geography. Intermediately between these two there is the class of survey which is so much in demand in the present day, and it is this class of work which I will endeavour now to illustrate. You may call the resulting map geographical or military, whichever you please, only observe that there is nothing vague or uncertain about the information which it professes to give. Military features are those to which the greatest prominence is given. Geographical features, pure and simple, which have no bearing on military questions, are, or should be, subordinated, whenever it is a choice between the two, as to which can be represented under the conditions of survey; and yet all features, whether rough or impassable mountain country or desert, whether well-populated and interested by high roads, or the cultivated valleys which usually form the best military highways, are equally based on that framework of well-fixed points to which I have referred. Thus it is a systematic survey, and must be classed as distinct from reconnaissance or exploration, though both of these forms of topographical illustration may find their place in the final compilation. It would be simpler to call these primary framework "triangulation," but the word might be misleading. Triangulation as systematic as possible is always aimed at, but it is not always possible. In the class of geographical surveys which is carried out *pari passu* with extensive military or political operations in the field, time is always the dominant condition by which the work is regulated and governed; and it frequently happens that the instrumental work of triangulation and the graphic process of topography must move hand in hand, the latter depending on the progress of the former from day to day. Our first consideration, then, on taking the field is to gain time, and it would be well if the survey staff were always placed in position with the first possibility of advance. To carry on a connected and well-balanced series of triangles with a force on the march is rarely practicable. Certainly no scheme for accomplishing this can be arranged beforehand, for the very essence of any such provisional scheme would be a knowledge of the country, and of the position of its most salient topographical features; and this is exactly what is wanting. It may happen, and, indeed, it does frequently happen, that by the subsequent reduction of all observations taken without any premeditated scheme, a more or less irregular series is finally evolved, and the possibility or the chance of this has always to be carefully borne in mind by the triangulator, who selects his stations as far as possible consistently with this object, and is ever on the watch to turn his broken line of observations into more or less systematic triangulation. Favourable conditions of configuration of ground, with evenly balanced distribution of mountain masses and plain, combined with favourable conditions of atmosphere, will so far help him that under the usual pressure of time and opportunity he will generally succeed; but success must not be anticipated with too much confidence.

As the American and Continental methods of geographical surveying involve the use of graphic triangulation very largely, I will point out shortly where the difference between the problems with which the surveyors of those countries have to deal, and those of our own geographers, chiefly lies. The American surveyors have enormous tracts of unmapped country before them, presenting, as a rule, much the same physical conditions of climate and configuration that we find in Asia, in those countries with which, at present, we are more immediately concerned. The area is so large in both cases, that it may be said that all the varied conditions of physical obstacle to progress are probably involved in both. But geographical surveying in America can at least be carried out with all advantages of leisurely consideration and opportunity, and with the aid of artificial assistance in the construction of suitable points for observation. There is nothing haphazard about these methods of procedure. It is always possible (or should at least be always possible) to select points which will satisfy the conditions of a properly balanced system of triangulation. American surveyors know beforehand what observations they must take, and can content themselves with securing their observations under favourable conditions of atmosphere with utmost possible precision. This, perhaps, is not the case with Russian geographers. In Russia there are often wide steppes and almost illimitable deserts of sand to be crossed without the aid of commanding points, which of all physical obstructions to surveying are the most trying. Their graphic triangulation is, therefore, very local, and cannot be said ever to extend to anything further than a minor series, or system, which may possibly embrace the area covered by two or three plane-tables at most on geographical scales. Beyond this they resort to theodolite work, but this again has hitherto been very limited in Trans-Caspian regions, and is applied rather as a check to the topography than the basis of it. Astronomical determinations of latitude and chronometrical longitudes are the final means of reference for the ends of a long line of survey, and these, however exact in themselves, can never compete with direct triangulation in the matter of precision. As a rule, we English surveyors have much more in our favour as regards the configuration of the countries with which we have to deal than the Russians, and instrumental triangulation, or some analagous method of securing a basis for topography, is almost always a possibility, and it would be a most fatal error to neglect it. On the other hand, we have no time for consideration, and very little in the way of preliminary mapping to assist us to a conclusion as to the most scientific line of procedure. The triangulator is launched into an unknown country, with perhaps the opportunity of effecting a good start from a well fixed base by visiting the two ends of a side of a triangle belonging to an already established series; perhaps he has only the opportunity of interpolating his position at starting by observations to distant points already fixed from some such series; in which case he must measure a base for himself, determine its azimuth and commence by fixing whatever he can find to fix in the direction (not always very certain) in which he expects to move. In no case whatever can he find artificial marks or signals to observe (except as regards his own base), and he has to determine the exact point to which his observations were taken without any sort of artificial assistance when he reaches it. As a rule, he must never expect to be able to revisit a station once passed. It does happen, of course, that a second visit is occassionally rendered possible during the ever-changing vicissitudes of a campaign or political mission, but he must not expect it. It follows, then, that the guiding rules for the triangulator at starting are at least simple. His aim must be ever to reach the highest points possible, embracing the widest field of view, having an eye rather to altitude and command, than number of stations or multiplicity of observations; and from each position in which he sets up his theodolite he must observe every possible point that may hereafter be turned to account, either as an interpolated fixing for the benefit of topographers, or as part of a connected series hereafter to be evolved, for obtaining the continuity of triangulation. Although this seems simple, it demands the constant exercise of a man's judgment, his memory, his physical capacity of getting over ground, and his quickness of perception. A really good geographical topographer is rare, but a first-class triangulator is rarer still. His judgment must be exercised as to what is possible within limited time, and the short opportunities that may be offered; he must not grasp at too much, and he must make the most of what he is sure of. He must depend on his memory from day to day, not only to decide on what he may expect to see from a point of given altitude within his reach, but for what it is positively necessary that he *should* see. A memory for ground, and that quick recognition of landmarks under their most curiously different aspects from different points of view, is a rare talent of the greatest possible importance. No one who has not travelled through rough country and watched the gradual changing of the features of the landscape as he moves forward—sharp pointed, needle-like peaks gradually transformed into long, flat-backed ridges; points that once stood out prominently against the clear sky dipping apparently into deep shadowy hill sides; or the well defined crest of a mountain as seen from the plain, gradually sinking to the position of an insignificant outlying spur when viewed from increasing altitudes—can form any conception of these apparent vagaries of nature. Imagine, if you please, the not very infrequent case of the triangulator pushing his work forward through a mountainous country at a late season of the year, when clouds are pretty sure to harass him and destroy his view, and occasional storms may be expected. It may very likely happen that want of provisions or the exigencies of service in the field, may make it absolutely necessary to push forward, regardless of the interests of his work Day after day may be lost in fruitless efforts to obtain a clear view from positions which must often be selected at haphazard, and which, when attained, offer no better prospect than an uneven, ever-moving sea of clouds, in which all that he may specially wish to distinguish is impenetrably shrouded. And then, after days of patient labour and unrewarded toil, perchance a bright clear panorama may suddenly open out. But what a change has come over the landscape! In the first place, his own point of view has shifted some scores of miles, and although if he climbs high enough he may still, likely enough, see the same ranges and the same peaks from a new and more advanced position, the whole face of nature has changed as in a transformation scene. A dazzling white veil has perhaps been drawn over it. All his carefully observed and treasured little landmarks, denoting certain points which must be observed with precise care, have disappeared. A line of comparatively insignificnt hills is suddenly magnified into an imposing mass of snow-covered mountains, whilst the really prominent peaks on which his careful scheme of work depends have not only lost their distinctive altitude and characteristics, but have changed also their apparent relative distances. Nothing destroys perspective and plays such tricks with the power of estimating distance as snow. The problem of fixing his own position with certainty and accuracy seem at first to be beyond solution to the triangulator.

Here, therefore, comes in a feature in the art of geographical surveying which should be carefully remembered. It would often be impossible to solve that problem if, along with his theodolite observations, he did not carry a plane-table reconnaisance chart. Both instruments are necessary. It is only with the chart in front of him that he can gradually evolve a correct estimate of his new position relatively to his surrounding points. By degrees, one after another of his noted landmarks assumes its correct distance and locality. Two or three a little better defined than the rest, by altitude or shape, give the key to the whole network, and in amongst that network there would undoubtedly be many which nothing but the assurance given by this plane-table chart would render recognisable at all. If, then, a plane-table chart, or rough reconnaisance carried on alongside the theodolite observations, is so necessary, why, it may be asked, should not the whole triangulation be graphic, and be carried out with the elaborate instruments and telescopic power used by the American and Russian surveyors? For this reason. In the absence of artificial signals and marks, it is absolutely necessary, in order to produce really satisfactory results, to select certain natural indications, such as pointed rocks, small trees, or other comparatively minute objects, for observation. It often happens that the actual highest spot of a peak is fairly defined and can be determined to within a few feet, but this is not always the case, and the great mass of landmarks on comparatively low elevations, that serve the purpose of the topographer best, are such as I have described. Now, although the plane-table ruler, or alidade, will point out on the chart the approximate position of such points, when once the station of observation has been fixed, and the plane-table is correctly set up in azimuth, it will often fail to show which of several rocks or trees is the actual one to which previous observations were taken. Nor would it be possible, without introducing endless confusion into the chart, graphically to project rays to points which may be within a few feet of each other. Is it necessary to preserve such accuracy? Yes, it is, in the triangulation, although much greater laxity of observation may be permitted to the topography. It is the aim of the triangulator to find his own position correctly on the earth's surface to within a few score feet of the truth, at the end of a series of operations that may extend for thousands of miles, and this can only be done by minute attention to small details in observing. At first sight, such a degree of accuracy in the rough and ready method of proceeding which geographical surveying implies may appear an impossibility, and it would almost seem to be straining at gnats, or splitting hairs, to insist on the identification of small individual objects when one's base measurements depend on a chain, and one's azimuthal values can hardly be trusted to within half-a-minute. But results show that it is worth all the trouble, and it is in this particular that we must insist on the value of a written record. To observe *everything* is the rule; not only what you fancy is right, but what may possibly be right; and to keep the record. Not all at once does the continuity of a regular system of triangles develope itself. It will require much painstaking examination of the records, many trials and many failures, before the computations prove that you have satisfactorily observed precisely the same feature from many points of observation, and that you have really secured a practical and continuous scheme of accurate triangulation. You *must have* that record if you mean to have satisfactory results, and however useful your plane-table chart may be to you as a general guide, it cannot keep that record for you.

Thus we see that there are three or four very distinct objects gained by triangulation with the theodolite, and the preparation of a registered record.

We claim in the first place that:—

(1) It secures accuracy to a degree unattainable by any other method, accuracy which we may claim to a certain extent to serve true geodetic purposes.

(2) The record is a very important gain to the general results. It is never possible to say to what extent or in what direction the work of one season or of one campaign may be carried forward in another. There must always be, therefore, as it were, an outlying fringe of observations which have no immediate practical bearing on the present map, but of which it is impossible to foretell the future use and advantage. These are better preserved in the book form than in any other way.

(3) There are obvious advantages, which I need hardly detail to you, about the entire scheme of triangulation being, as far as possible, the result of individual ingenuity, and emanating from one source. Independently of the gain in simplicity of scheme, it is manifestly an advantage to geographical interests that some one or two individuals should possess a comprehensive grasp of the whole configuration of the tract passed over, and that they should be able to balance the maps of many topographers, with their varied styles and idiosyncrasies, one against another, and so give the index to a

uniform system of mapping. In the Russian system of graphic triangulation each plane-tabler carries out his own triangulation, thereby covering his ground more than once, and losing considerable time. There is no one central authority for the general geographical delineation of the country, each man's information being confined to his own narrow plane-table limits; unless the cartographer, who is distinct from the topographer, should be able to see all the ground for himself, and map the whole district. Our topographers are also our draughtsmen and cartographers, and we must, therefore, have a guide for the production of a level and uniform style of drawing.

(4) We must bear in mind the great advantage that is gained by perfect freedom of action on the part of the topographer. With the knowledge that within the limits of his work there will be a sufficiency of points for final reference, both to check his scale and the values of his interpolations, he can utilize his chances as they occur, completing the topography of important parts first. He may not necessarily be provided with this primary basis before starting, (although he should be so provided if possible), but whether he is or not, he knows that final adjustment is a certainty; and if he is, then he can take up his work when and where opportunity may offer. He has nothing to say to other workmen. His own topography is an independent unit. With triangulation to support him, linear values, compass, or azimuth error, and even hypsometrical determinations, vanish from his programme. All this is settled for him, and (please note this particularly) he can accomplish his work with the very roughest and simplest form of instrument that ever was devised. Our field plane-tables are simple even to roughness. So long as they are strong enough to be carried in any or every sort of fashion, that is all we require. So that for the introduction of one theodolite, you may simplify at least half-a-dozen plane-tables to the crude original of a plain deal board with a motion in azimuth. I doubt whether we do not gain even in the matter of simplicity of instrumental equipment by the free use of the theodolite. I have purposely avoided all details of the nature of the actual observations themselves, believing that the instructions you receive at Chatham will have taught you all that you need to learn as to the art of using the theodolite for ordinary triangulation. There are little artifices and 'dodges,' of course, which might well be worth attention if time permitted, but time does not permit, and I will only say that we regard no observation as complete, either vertical or horizontal, till it is taken and recorded on both faces of the instrument.

So far we have dealt only with the problem of carrying out continuous triangulation, on the supposition that time and opportunity (by which I mean the opportunity offered by the configuration of the country under survey, as well as the opportunity that may occur of leaving a continuous line of route for the purpose of visiting outlying mountain ranges or other points of advantage) are favourable to such operations. But they very often are unfavourable. Narrow deep valleys intersecting a comparatively level plateau may block out an extended view, and present no facilities for distant observations, even if the apparent water-shed on either side the valley can be reached. It may, too, be impossible to leave a line of route for any distance without a strength of escort that would hopelessly impede the necessary rapidity of action; or unfavourable weather, thick haze, rain, or snow, may last for days, and hamper survey work indefinitely. Under these conditions, the connected and continuous building up of a series of triangles must be abandoned, and recourse must be had to traversing.

Traversing, in its simplest form, implies the measurement of the distance passed over with the record of direction, and the delineation of topographical features on the basis of that measurement. We have found that of all systems of route measurement, that of the perambulator, or measuring wheel, is the most practically useful. Chaining is far too long and cumbersome a process, the measurement of distance by record of the angle subtended by any short base, such as a ten-foot pole, for which special instruments have been devised, though exceedingly useful for local purposes, such as the traverse of exceedingly rough ground unimpeded by jungle or vegetation, is also too slow a process for the rapid movement of a force, some 10 or 12 miles of traverse being all that is practicable in a day by this method. With the perambulator as much as 30 miles has been accomplished in a day's run, over ground fairly favourable for a single wheel, with no very great error. It should be noted that the flat plains and narrow valleys which prohibit triangulation are generally favourable for traverse. When rough and rugged mountainous country is reached, triangulation again becomes in general a possibility. The angular measurements which accompany the traverse can be taken by the old method of observation with a prismatic compass, with a record to be subsequently plotted, or they can be, perhaps, better effected by use of the plane-table, with the additional advantage of locally executed topography. Where one method only can be adopted, I strongly recommend a plane-table traverse, and the completion of the topography *in situ*. But if the traverse is but a link in an otherwise fairly connected scheme of triangulation, every available means must be adopted to ensure accuracy. In such a case two or three measuring wheels should be run, and the record of each taken from point to point. The angular record of the prismatic compass should be added to the graphic work of the plane-table, so that whilst the latter answers all practical purposes of reference from day to day, the former is a useful check to hold in reserve till leisure and opportunity offer the chance of revision. As regards astronomical checks, which can be usefully applied to such a traverse, much depends on its general direction. So long as it preserves a general trend from north to south, latitude checks are most valuable, and should be constantly employed. There is, however, no known method of determining absolute longitude which answers the same purpose, with a traverse running from east to west. Even differential chronometrical determinations are unsatisfactory, and at best but an imperfect means of checking distances, when the traverse extends over such an arc of longitude that it cannot be trusted to be accurate within a mile or two of absolute position. The difficulty of carrying chronometers without disturbing their rate, and the necessity of a lengthened series of time observations in order to re-determine a rate once disturbed, places chronometer reckoning at such a disadvantage in all rapid surveying that, practically, the method has been abandoned. But conditions which compel the adoption of a simple line of traverse are so exceptionally unfavourable that they will not often be encountered. As soon as a wide view is practicable, and the landscape becomes diversified by alternations of hill and plain, the introduction of more rigorous methods of procedure becomes possible, although still the ordinary forms of triangulation may be unattainable.

To keep up a long and yet well-connected line of survey at a rapid rate of daily progress, to furnish points on which the topography is based, and to avoid any large accumulation of error after traversing many hundreds of miles, is a problem which has been very frequently encountered and fairly successfully dealt with of late years. By far the most successful system is that of the continual measurement of fresh bases, with a limited amount of triangulation from the two ends for the adjustment of topography; and the connection of these bases by a double line of traverse such as I have described. The procedure is as follows :—A daily traverse is run both with the plane-table and a recorded check. On the plane-table all topographical details are entered, and the plane-tabler, whilst utilising the traverse to fix his position from time to time, still can reach points of vantage, at short distances from the route, from which to obtain an extended view under favourable circumstances; he will thus cover a wide strip of country. Meanwhile, a separate party hurries forward over the day's march with all possible despatch, and at the end of it selects the ground for the base. Of all systems of base measurement in the field that have lately been tried, we have found that of using a steel chain, and repeating the measurement about three times, the most satisfactory. In the hands of long-experienced chainmen it is surprising what accuracy can be attained, and it has the advantage of employing subordinate workmen instead of taxing the time and energy of superintending officers. Still I cannot help thinking that we have something to learn in this particular. We want a more rapid method than chaining, and geographical surveyors would be lastingly indebted to the inventive genius of any officer who would devise some simpler form, equally trustworthy, which can be safely committed to well-trained subordinates. Where rough ground only presents itself, other methods are, of course, made use of, but they invariably demand the use of angle-measuring instruments, and the employment of a careful observer, who has plenty of other work on his hands. During the hours of daylight, the two ends of the base are visited and observed from, special care being taken to observe the farthest points in advance on the line of route, and to select at least one or two well-marked points. Possibly a third station might be found and connected with the base. As daylight darkens, and the stars appear, no time is lost in getting the necessary astronomical observations in order to determine—1st, Time; 2nd, Azimuth; 3rd, Latitude. I will not trouble you with too many astronomical details, but refer you to that excellent work, *Hints to Travellers*. It is here that the full value of the six-inch transit theodolite, with a full vertical circle reading to 10 seconds, comes into recognition. Time and azimuth are observed simultaneously, the same stars, east and west of the meridian, serving for both, and the same observation recording both altitude and angular horizontal distance from the referring mark. For this, I need hardly say, you require to observe the star at the intersection of the vertical and horizontal wires, an observation which is much simpler than you would at first suppose. Observations are taken in pairs, on both faces of the instrument, to stars both east and west of the meridian. That completed, stars north and south are selected for latitude, the pole star being generally balanced by some south star that culminates at a convenient hour for observation. Of course, the value of the results depends on the care taken to keep the instrument steady, the absence of wind and clouds, the lighting of the wires, and many other small details, amongst which are causes of irregularity for which you are not responsible. Consequently it is necessary carefully to record the conditions of observation in each case, so as to balance conflicting values afterwards. When these observations are completed, you have a fair amount of computation before you.

With the true latitude, the correct azimuth, and length (say two miles, though it is seldom possible to secure quite such a length) of the base, you can plot its absolute position on the plane-table, accepting its longitudinal value from the traverse, corrected proportionately to its ascertained error in latitude. You then compute and plot by azimuth and distance the points you have observed. Some of them have been seen before, as your plane-table rays indicate, and herein comes an immediate check. Thus each day's work becomes a complete unit in itself, connected with the last day's work both by traverse and by observation to points common to both; the latitude is preserved by continuous and repeated absolute determinations; longitude by repeated azimuthal observations to commanding points near the line of route; and when your final compilation is put together, and the whole scheme reduced to a map, you will probably discover that good luck has backed up good management, and you can, by more than one continued and connected line of azimuthal observations, the full bearing and value of which was not always apparent at the time of observation, determine your position in longitude almost as exactly as in latitude. To give statistical details of the probable errors in final result, after traversing many hundreds of miles of fairly open country on this method, would only be misleading, because in many cases these results can hardly yet be weighed and balanced by the light of rigidly accurate geodetic facts. They are in themselves mostly the first approximations to the truth, and it is wise to say no more than that the error is inappreciable on geographical scales of mapping.

With the first-class little instruments now in use for the survey of India, a latitude should be determined to within about two seconds of probable error in arc; and azimuth to within 20 seconds of angular measurement; and time to a fraction of a second. Base measurements with the chain should be correct to about 0·001 of linear value. Although I have here described a system of repeated base measurements and constant determinations of azimuth as applicable to a connected route survey on scientific principles, yet I would specially draw your attention to the value of both as a constant check during the progress of more regular triangulation. Indeed, I attribute to the repeated introduction of fresh linear values, and fresh values in azimuth, the almost unexpectedly close results which have lately been attained and satisfactorily verified, at the conclusion of long and varied geographical survey operations extending over many thousands of square miles. There was no fixed rule for the introduction of such values. They were applied whenever the opportunity was particularly favourable for base measurement. Nor are repeated observations for latitude at all to be neglected, even when triangulation is regular and well balanced. If they serve no other purpose, they may frequently throw light on questions of level deflection, which enter so largely into the complicated problems of geodetic science. On the difficult and tedious processes of determining absolute longitude I will not now enter, having had no recent experience in such determinations. So long as any system of direct triangulation can be carried forward, such determinations are unnecessary, and add nothing of value as checks on absolute geographical position. They are, therefore, much better left alone. A single azimuthal observation to a far distant point already fixed on the earth's surface, bearing, approximately, either north or south of the observer, leads to a far better determination of longitude than any astronomical observations can possibly do. But where a telegraph exists, there at once is the means of ascertaining by interchange of time signals a differential value which may be of the highest importance, and this method of obtaining a starting point for geographical operations in unmapped countries is one which we have found of the greatest practical value.

Thus far I have dealt only with the means that have been found most applicable to the establishment of that basis of accurately fixed points, scattered at intervals over the wide area of survey operations, on which the mapping subsequently depends. Now as the map, or the actual topography, is after all the final end and aim of it all, you may ask why I have given precedence to triangulation rather than to topography. I have done so because it is least understood, and its importance is so constantly overlooked. There can be no scientific geography worthy of the name without it, and yet in its initial stages, and indeed during the entire course of its development, there is nothing to show for it, no practical outcome which can be made readily intelligible to those in whose province it lies to decide, under the military or political exigencies of the time being, what may or may not be attempted in the way of survey. The constant and urgent demand in the field is for maps for practical use in guiding operations; and with the small, and frequently very incomplete, staff of surveyors that our English organisation allows in the field, it is sometimes very hard to convince authorities that all our energies should not be devoted to the one object of mapping the country we pass through, irrespective of the possibility of fitting all the patchwork of topography scientifically together. The temptation to abandon the attempt, especially as it involves most constant labour and attention, and let subsequent compilation take care of itself, is often strong; but, as I have already pointed out, facility in subsequent compilation and general accuracy is not the only advantage gained. Topographers can work far more quickly, and utilize their opportunities far more readily, with the triangulation to lean upon, than they can possibly do if left without such assistance. There is, in reality, no loss of survey power involved, although it may appear occasionally that time is lost. I wish to insist on the application of your work to true geographical purposes. There are some of you—the majority in fact—who will never take up this speciality; nor indeed would it be at all desirable that we should all be surveyors at the expense of many other important branches of military science. Some of you are not draftsmen, and possibly I may not be very far from the truth if I say that you waste a good deal of time in half-hearted attempts to master a special subject for which you lack the special aptitude. Now to you, too, (indeed to you especially), is the theory of the art of geographical map-making important, for the very reason that the practice of it will never come in your way. For you may rise, some of you, to positions of command hereafter, when it may rest with you to decide how to employ the labours and brains of others to the best advantage. You will be able to do more damage to the interests of geographical surveying by a complete misunderstanding of the subject, than all the bungling of a whole staff of half-trained workmen put together could do. I cannot plead too strongly for an universal theoretical acquaintance with the principles on which geographical mapping depends. These principles in themselves are old, but the methods of their application are new, because the general improvement in the standard of instruments used in the field, and especially the substitution of the plane-table for other topographical systems of work, have put fresh power into our hands. I cannot but believe that with a more widely distributed understanding of the advantages to be gained by systematic scientific geographical surveying, its rapidity in securing intelligence, its cheapness, and more than all its general accuracy in results, that there will gradually arise an infinitely more comprehensive organisation for securing trustworthy information than exists at present, based on the same scientific principles and methods.

We have indeed, as I have already said, a fairly well proved and well tried system, but no general organisation. The application of scientifically trained workmen to the acquirement of thoroughly good information is at present special, local, and spasmodic. Remember that with geographical mapping you have by no means arrived at the final end of your endeavours. It is true that we surveyors are held to form purely a map-making department as distinguished from the intelligence and political departments, which are not map-making, but which require our maps to illustrate their information. A good map, as has justly been observed centuries ago, is the best exponent of all such information. The directors of our foreign policy can no more do without it than the directors of our campaigns. Consequently you can never afford to neglect a constant study of the particular points which may be useful to both, and you must ever be prepared to add to your map statistical and special information, bearing on matters with which you must perforce be in contact, of military and political significance. It is of no use to maintain that questions of strategy, ethnography, and what we may call military statistics generally, should be left to another department and a separate staff. Very frequently, indeed, the geographer goes farther, and is in a position to see more than others can possibly see of the relations either purely civil and commercial, or military, between his own country and that of others, and it would be a distinct neglect of duty not to bring back with him as full a report on all these subjects as he is capable of making, together with his geographical illustration of country. I may say that hardly a single native geographical explorer goes out with his plane-table who does not eventually furnish a report to the military authorites as well as his civil superior. Thus you see that whilst regarded as a specialist, you must be prepared to lend a hand to others around you, who are working maybe for the same ends, but belonging to other departments of the public service. Military exigences will be those which will regulate your actions in the field, and if you wish for a successful record you must give and take assistance from all military departments around, especially working with the closest accord with officers of the intelligence and Quartermaster-General's staff, although not quite on the same military footing.

Whilst on this subject, I may say a few words as regards the one great defect in our system, a defect which has only become prominent since we have learned to increase our original material so rapidly; and that is the want of power of reproduction. At present the greater part of our trans-frontier military mapping is secured under most difficult conditions during the progress of military operations. With a more comprehensive organisation for such work, which we yet hope to see, this great disadvantage may be remedied, and we shall be able to put maps into the hands of our military chiefs which will serve to show how a campaign should be conducted, and not merely what was done after it is all over. But as matters now stand we get more original material in our hands as an expedition progresses than we can find time to reproduce. We are dependent on tracing, a laborious and tedious process, which employs the time of men who are urgently wanted in the field. Our maps, after being traced, are sent out of the field to the head office of the department, there to be printed, and are then sent back again, often after the urgent necessity for them has passed away. I am already much indebted to some officers here for their assistance and advice on this subject, but I cannot help thinking that there is room yet for further consideration, and that we have hardly reached a final solution of the problem.

In conclusion, I may be permitted, after many years' experience, to offer a few words of advice to those who contemplate making geodetic and geographical science a speciality. And what I say shall be based on what I have seen of the work of young officers fresh in the field from the S.M.E., or from the Staff College. The great tendency of all beginners is to work for their own hands. So far from being deprecated, this tendency is very much to be applauded up to a certain point. Individual energy and enterprise are exactly what we want, combined with a good physique and unlimited capacity for work, but the point where the line should be drawn has been passed when the ends of geography and the aims of military information are subordinated to individual love of adventure. To get the greatest amount of information often appears a very inferior object to the excitement of some particular enterprise, and we cannot wonder that officers are apt to scorn the humbler *rôle* of directing the efforts of others aright, and to prefer the satisfaction of what they call "doing their own work." But they will often do their own work best after all, and certainly economise their wits and their own brain power, by working through the brains of others. This most especially applies to India. Bear in mind that for months, and perhaps even years, after you have taken your place in the field, no matter what skill as a topographer you have acquired in the military schools of England, you will not be able to place your work alongside that of a well trained native, except to your own disadvantage. For patience, endurance, accuracy even, and skill, the best native workman will be your equal, whilst for power of making his way about, of acquiring local dialects, and of making himself thoroughly at home in a foreign country, he will beat you hollow. Many a man goes out from England, armed with a certain amount of skill as a surveyor, and full of energy for the purpose of exploring a new country, who brings home with him a fresh fund of geographical information; and his work may prove creditable to himself, and of the utmost use to the Government he serves in many particulars. But he should carefully ascertain (I am speaking more especially of the countries bordering India) whether native explorers have been over the ground before him, and if so, what information they have already furnished to Government Otherwise he will most certainly waste a great deal of most valuable time and power of observation in doing that which has been very much better done before. Remember that the value of your brains and of your knowledge may be multiplied almost indefinitely in the brains of others and the knowledge you can impart to them. It is, indeed, a most tedious and sometimes most ungrateful process, the selection and education of natives for geographical work; and it is a duty which calls to itself little attention, and consequently may pass comparatively unrecognised. But the results, if you have geographical interests at heart, will amply repay your time and care. You will do more in the end, and you will do it more scientifically, too, than a Stanley or a Prejvalsky. This all-important subject, the proper employment of a native staff; what they can be expected to do better than Europeans, and where they fail, I must reserve for another time. With it commences the question of topography, the second chapter as it were of the general subject of geographical surveying.

As regards instruments, the two chief instruments, to which all others are more or less accessories, are the theodolite and plane-table.

As to the former, I may bear testimony to the value of the six-inch transit theodolite, fitted with a micrometer eye-piece, which gives the power of measuring small angles without shifting the horizontal plate, and so determines distance by means of subtended angles, whilst also incidentally furnishing the observer with two extra wires for astronomical observations. I may add that we find that theodolites answer best with the vertical level fitted to the vernier arms rather than to the tube of the telescope, which enables one to read the level on both faces instead of one only. Also that the cross-wires of the spider-thread pattern, intersecting at right angles, are better for illuminating at night, and more convenient for astronomical observations than those cut on glass. For a fuller description of the theodolite that answers geographical purposes best, and the nature of the observations that can be taken with it, I will again refer to *Hints to Travellers*, where a far more complete description of it is given than I can possibly add to a paper of this sort. Therein, too, you will find so much useful information on the subject of barometric records and the use of hypsometrical instruments, that I will omit reference to this interesting but most complicated subject.

LECTURE II.

TOPOGRAPHY.

In the first lecture we dealt with the necessity for a scientific basis on which all geographical mapping must rest, and I endeavoured to show you that the more widely distributed the area over which geographical survey operations had to be carried, the greater was the necessity for accuracy in the triangulation system. Not so very many years ago geographical triangulation, of the nature which has been so much developed lately, would have been reckoned a practical impossibility. Fifty years ago nothing of the sort was attempted; our military surveyors were then contented with local route surveys, and a system of patchwork reconnaissance which only served local and temporary purposes; and although we cannot say that the subsequent compilation of these shreds of map work resulted in no geography, we can certainly say that the compilation took years of patient research, and much discussion as to authorities that could not be made to agree, and that the result had no claim to be considered scientific when accomplished. What should be our aim now is sufficient exactness in measuring the earth's surface, to assist science in theoretic questions of geodesy, as well as to serve the purpose of topography. If we have not entirely succeeded to our own satisfaction in attaining this end, we are at any rate well on the way to succeed. We know the weak links in our chain, and the future will undoubtedly bring opportunities of strengthening those links, and meeting theoretic as well as practical requirements. Meanwhile the practical requirements have been fairly well met wherever geographical surveying has been carried. We can give the explorer or the topographer the measure of his scale and the basis on which to rest his mapping. What he wants now is a thorough understanding of the proper use of such data as we can give him. I will commence by briefly describing the ordinary methods of carrying out topography in the field, under the usual conditions of pressure as regards time. I say the usual conditions, speaking only of my own experience ; I do not mean that the governing principle in this sort of work must necessarily be rapidity, only that it has been so as a general rule hitherto, and the first consideration that has presented itself to the officer in charge of such survey operations, has usually been how to get the work done rapidly. The quickest, simplest, and most comprehensive system of covering ground and of obtaining accurate topography, is undoubtedly that of plane-tabling. This is, I think, now almost universally admitted, and although for special purposes, such as are aimed at by the Ordnance Survey of England, for example, plane-tabling may not appear the most effective method of topography, yet I think that for geographical and military purposes its advantages are now so universally recognised by every civilized and scientific nation, that I need waste no time in detailing them. Ten years ago, when I was interested in the re-introduction of plane-tabling into the course of English military instruction, I was unable to find in England an instrument to illustrate my views. Now I will take it for granted that you are all tolerably familiar, at any rate, with its application to topography, and general manipulation. I may mention, incidentally, that my friend Mr. Pierce, a gentleman who has had large experience in American surveys, who has recently taken great pains to trace the history and origin of the plane-table, has found old records that carry it back to the 13th century; and that it is clear that its use was understood in England even earlier than that. Although we have come again to borrow some of our ideas of its scientific application from our Continental neighbours, yet still I feel a certain satisfaction in claiming this most useful instrument as of English extraction, and I confess I feel much difficulty in accounting for its temporary eclipse amongst English scientific instruments. It is also a satisfaction to me (for which again I am indebted to Mr. Pierce) that I can now call your attention to as perfect a specimen of a plane-table as has, perhaps, as yet been invented, instead of illustrating my views in this Institute, as I did ten years ago, with an instrument of very primitive construction. The advantages of this American instrument are the advantages of refinement. It does not claim to accomplish much more than the rougher pattern, but the work which can be done with it is more accurate. I will not describe it in detail, as you can better examine its construction for yourselves, and Mr. Pierce will shortly have something to say about it. It is specially adapted for the work of graphic triangulation, and in conjunction with the alidade (which takes the place of our plane-table ruler) becomes also an admirable levelling instrument. You will observe that the alidade is furnished with a telescope working on a full vertical circle, and with cross levels to assist in levelling the table. As the table itself is provided with a slow motion screw for adjustment in azimuth, it thus becomes a triangu lating instrument of considerable power; its powers of accurate intersection being very much greater than those of our own instru ments, and, probably, quite equal to those of the smaller class of theodolites. Added to the plane-table and alidade, is another small instrument, called the solar attachment, by means of which the plane-table can be oriented, or correctly adjusted in azimuth, by means of observations to the sun, so long as the latitude is known ; and it is thus rendered independent of uncertain triangulated points, or of compass error. I think I may as well say at once that no such plane-table as this has ever yet been applied to the practical purpose of geographical surveying in English hands. This is not the sort of instrument that we give to our native surveyors to be slung on a mule or balanced on a camel, to be dragged over rough places, perchance blown over a precipice, or dropped into a river. I do not mean that this is ordinary procedure by any means, but accidents will happen, and we must provide against them. My only objection to this admirable instrument is that it is too good. We could not afford, as a rule, to take into the field anything so complicated or refined. I have already endeavoured to prove to you the advantages of a recorded and computed triangulation, and pointed out the necessity of carrying the theodolite for astronomical purposes as well as triangulation, and I must insist, as far as I can, on the further advantage of simplicity in construction, of such instruments as are put into the hands of topographers. Instruments of the class now before you, not strictly following any required pattern, but fitted with slow motion in azimuth and adding telescopic power to the alidade, are used by the Russian topographers for geographical purposes. But they appeared to me heavy and complicated, and I may be permitted to say this much, perhaps, that, with the greatest admiration for the organisation of the Russian Military Topographical Staff, and of the skill and devotion to duty evidenced by the Russian topographers themselves, I do not admire their instruments, and I prefer our own system of elaborating a distinct triangulation. Our instruments are well enough known to you: a simple, plain, well-seasoned board of teak or deal on a folding tripod stand, the board being attached to the head piece by a thumbscrew, as strong as it can be made, and as large as can be conveniently carried, in order to allow space for as many scattered triangulated points as possible, is the plane-table of our geographical surveys at present. Instead of the alidade, we use a simple ruler with bevelled edge, and folding sights at each end, similar in all respects to those of a prismatic compass. The 'trough' needle or compass, by which the approximate azimuth is most conveniently determined, is six inches long, and plays through about 20 degrees of arc only, and if the topographer is further provided with an aneroid barometer for the determination of differential heights, he is generally fully equipped. For mounting the board, we have found that cloth-mounted paper is perhaps the most convenient material; it is readily carried in rolls or strips, and can be quickly fitted to any plane-table and removed again at pleasure. We have never succeeded in adopting the system of carrying a continuous roll on the board, extending beyond the limits of the plane-table, and capable of being shifted as the work proceeds ; it has been found to be inconvenient in carriage. On the mounted board is projected, in the first place, the graticule of the district over which topography extends. This is all-important, and no geographical work is complete without this record of its position in the final compilation. Then follows the projection by co-ordinates of the computed points from the triangulation records. Their relative distances are again checked from the same computation by means of a beam compass. The triangulators have also determined the value of the compass error, and, armed with this, the topographer can at once commence his work from the nearest triangulated point on his board. And now we come to the leading principles which must guide him.

If possible, as I have already said, he commences his field work by visiting the nearest triangulated point that affords him a wide view over his ground, and from thence he should make himself acquainted with the nature and position of all similar points that are within view, determining the correct azimuth of his plane-table by sighting those which are most distant, and then marking carefully one by one the characteristics of the nearer ones. This noting of minute topographical distinctions, which serve to identify each point when seen again from another, and, perhaps, distant position, is the key to successful geographical topography. A topographical memory is not always an acquirement. Some men seem to possess it naturally, but it is rarely intuitive ; more often it is the result of long and careful study of the physical characteristics of particular countries, of long experience, and the constant practice of careful observation at all times. I have already referred to the remarkable way in which topographical features will appear to assume new shapes under varied conditions of atmosphere, or of their relative position from the observer. Recollect, those of you who are acquainted with the mountainous districts of Europe, that you will not find amongst the mountains of Asia, nor, indeed, so far as I have seen, in the highlands of Eastern Africa, anything analagous to the Alps, with which, perhaps, you are familiar. So many remarkable peaks with characteristic and unmistakeable individuality within so small a superficial area, exists nowhere in the Himalaya or in the high table lands which border our north-west frontier of India. Neither can you ever trust to native report for the correctness of your position; or for the names of such mountains and peaks as may be within view. It is this which makes it often so difficult, almost impossible indeed, for an inexperienced surveyor to ascertain his own position, to know exactly what point he has reached when standing amid a mass of mountains, faced by range after range of snow-capped spurs, all running nearly level and offering no prominent land marks for recognition. Do not imagine that you will often find peaks such as the Matterhorn, Monte Rosa, or Mont Blanc to assist you. In all my experience I have never met them, and I have often been amused at the confidence with which amateur explorers, with no sufficient means of knowing exactly their own position, have affected to discover that the Government surveys were utterly wrong, that mountains occupied the place of valleys, and that the valleys of the maps were formidable ranges. I have heard such assertions made even before one of our most scientific societies, by an enterprising traveller who had, apparently, no adequate means of determining his own position at all. Even an experienced surveyor, with all such means at his disposal, would have proceeded with caution (the more experienced, the more cautious he would have been) before declaring positively that he had interpolated his position correctly. There is a place near Darjeeling from which it is popularly supposed that Mount Everest, the highest mountain as yet seen in the world, is visible. Although it can be demonstrated without difficulty that in order to see Mount Everest from that comparatively low elevation, it is absolutely necessary that you should see through another mass of peaks not so high as Everest, but in a direct line with it, and bearing marks on their rugged sides that do not belong to Everest, yet still it is found almost impossible to persuade tourists that Everest cannot be seen from there, and many a well-known traveller has come back satisfied that he has seen and paid his respects to the monarch of the mountain world. So please dismiss from your minds the idea that it is an easy thing to recognise your triangulated points, however well fixed they may be, and remember that subsequent success may depend largely on the care and attention you bestow on minute features connected with them, after first recognition. On a triangulated position, with others in view, the topographer can ascertain at once if his compass error is the same as that recorded, and he will be wise if he brings the needle to zero, and carefully marks the position occupied by the compass, for future use, by drawing a line round it. It is much easier to bring the point to zero than to guess at an error which may include fractions of degrees not included in the graduation. For all future interpolations he will then be guided, in the first instance, by his compass in orienting his plane-table. It may happen (often does happen, unfortunately,) that triangulated points are very few and far between, and that topography must be commenced by an interpolation. Of course, you know that if there are three or more points properly distributed for reference, the interpolated position can very well be determined without the aid of the needle, and the correct azimuth ascertained, so as to check the compass error. But, alas, even these may fail. We have occasionally to launch a topographer into a district which may never be open to mapping again, very insufficiently supplied with points, perhaps even in advance of all triangulation, where he must be entirely dependent on his compass. His scale must be regulated by measured distances (probably measured with a perambulator), and he must bring in his field sheet to be adjusted finally on fixed points that have been subsequently determined. Now of all unpleasant complications that can arise in the adjustment and compilation of a topographical map, that of a twisting azimuth caused by variable compass error (for we are supposing a case of plane-tabling entirely dependent on compass) is the most trying and vexatious. It is impossible for the topographer himself to detect the variation, and not even the application of the triangulated points to the field map can set the difficulty entirely straight. It is under such circumstances as these that I forsee great future value in the solar attachment exhibited by Mr. Pierce. Here is a ready and portable means of determining the true azimuth of your plane-table and the amount of compass error, with facility and reasonable accuracy, so long as the sun is shining; and I need hardly observe that you will find quite enough sunshine for convenience in the countries with which you will have to deal. Let me particularly commend to the attention of all scientific surveyors an instrument which I believe to be thoroughly practical and useful.

On the very important question of topographical detail, both natural and artificial, to which the chief care and attention of the topographer should be given, what to represent with careful accuracy, and what to leave alone, it would be unwise to lay down any positive rule. You have, doubtless, been taught that a trustworthy map should be a faithful representation of all features which appear on it, that nothing should be left to conventionalities, but that all parts of it should be equally certain as a record of existing facts and features. But this equality of representation cannot, unfortunately, be often attained in geographical work, and in this, as in many other points, there is a great demand made on the individual intelligence of the workman. His efforts must be directed to the acquisition of as much useful knowledge as possible, within such limits of time as may be available, and to this end he will often be called on to decide, from the very commencement of his work, what calls for special and careful detail, and what may be left more or less to the imagination. There is, naturally, a general tendency in men who are introduced to this class of topography for the first time, to lose themselves in the intricacies of broken and difficult country, and to break their hearts over vain endeavours to unravel some tangle of configuration which time does not permit of surveying accurately. This is, of course, a serious mistake, for, as a rule, the difficult and knotty problems of geography occur just where the solution of them has no important bearing on military requirements. It is invariably the open country, fertile valleys, and well-populated districts, that present the most probable areas for the theatre of military operations. Even where passes and obscure routes occur through mountainous country, routes which may be all-important as factors in the military scheme, they will hardly be found in the roughest and most inaccessible parts of these mountains. So that a geographical surveyor will always be right if he gives precedence to high roads and open ground, in preference to the rough tracks of the hills. Yet it is a matter of constant necessity to explore those hills from point to point. No roads or passes must be omitted, and it is frequently possible to obtain a better and wider view of cultivated plains from even distant hills than can be gained in any other way. Thus, whilst the topographer is constantly occupied in ascending heights, he should remember that those hills and heights are not his topographical objective, and he should beware of the almost irresistible attraction of tracing out the watershed system with too much minute exactness, and of embellishing his map by elaborate hill-drawing at the expense of practical military information. Of course, I am assuming that a geographical map is a military map. For English geographers, in such countries as you are likely to deal with, it is. The great rule to be remembered is, never to confuse yourself with attempting too much drawing at first. Many of our best Indian topographers follow a system which, I have observed, is recognised by the Russians also, of actually representing nothing but the hydrography of their field maps, except by conventional signs known only to themselves, until the time comes for the final completion of the topography by fair drawing. The disadvantage of the system is obviously that, should a topographer be cut off before his map is complete, no one can complete it for him. Otherwise I should say that the results obtained in this way are more accurate (inasmuch as it is a quicker process to make a conventional sign representing so much detail than to draw the detail itself, and consequently they may be made more frequently and be more closely packed) than by the ordinary process of delineating what is seen whilst it is yet under his eye. It is a far more rapid way of working than any other that I know, and, provided the surveyor is careful to reduce his conventionalities to black and white line drawing sufficiently frequent, there is no great risk. I have seen the work of months represented by an almost blank sheet of paper, with the exception only of careful drawing of the drainage system ; yet that sheet finally developed into a minutely accurate representation of many square miles of most intricate ground, in a Russian cartographer's hands. I am very far from recommending any beginner to attempt such a system as this. The chance is considerable that he would forget the meaning of his own signs. I only quote this example in order to enforce the principle of avoiding too much drawing at starting.

We will now consider the best method of representing ground in geographical mapping ; whether by an approximation to continuous contouring, by vertical shading, brush work, or horizontal hachuring. There can be no doubt that the most scientific method of expressing inequalities of surface is by means of continuous contours. American surveyors apply this principle to all mapping on all scales, whether geographical or detailed plan drawing. Through the kindness of Mr. Pierce, I am able to show you some specimens of American geographical mapping, in which you will see that the continuous contour system has been made applicable to country embracing all possible conditions of configuration, and if the hypsometrical information thus conveyed is only fairly accurate, nothing, to my mind, can convey a more perfect impression of the configuration of the vast tracts which are represented in those maps. *Plate* I. is a photograph of a portion of a field map on a scale of $\frac{1}{30000}$; *Plate* II. is the reduction to scale of publication. The superior class of plane-table which is used in the American surveys, and its power as a levelling instrument, doubtless renders it possible to carry out this system of delineation by continuous contours to an extent that is not practicable by rougher methods. Yet the contours of a geographical map of this description are at best but approximations, possibly very rough approximations, to true levelling. Within such narrow limits of time and expense as condition the production of these maps, it would be impossible that they should be otherwise. The danger of the system then appears to me to be, that too much value might be expected from this manner of representing ground. Our ordnance survey contoured maps are, of course, as true representations of surface undulations as can be obtained by our methods of levelling; the contours are rightly accepted as being as faithful representations of the hypsometry of the country as the topographical detail is faithful in plan. A contoured map has, in short, a recognised value in public estimation, which it would certainly be well not to disturb. Were we to produce geographical maps on the contour system, I know of no method by which it can be made clear that the geographical contour must be accepted as of a different standard and value to those of maps on similar scales where the contouring at once stamps the map, as it were, with a definite hall-mark of accuracy. With the topographical detail it is different. Its general character and minuteness at once furnishes the key to the map standard. What there is of it should be thoroughly trustworthy, or else methods of representation should be adopted (inapplicable to contours,) which at once define the drawing as approximate. Whilst admitting the beauty of the continuous contour system, we must acknowledge that this beauty is largely due to the convenience and facility with which it helps the map reader to a comprehension of complicated detail. It is like reading a clear solution of a mathematical problem, compared to being furnished with the formulæ by which such a problem may be worked out. When the solution is perfectly correct nothing can be better, but when it is but an approximation to the truth, and when, moreover, it cannot be made quite clear that it *is* only an approximation, then I think it is best to content ourselves with the expression of such formulæ as we can get, in the shape of ascertained heights of certain marked points on the surface of the map. Brush work is very effective, and can be adapted to the minutest shades of gradient in accomplished hands, but, in India at least, we have long ago decided that the brush should be wielded only by an experienced artist; and we cannot always wait long enough for the acquirement of an artistic education before putting our topographers into the field. You must all of you have found that there is temptation in brush work to strain at effect at the expense of truth. It is too dangerous a method for the ordinary workman in the field. Between horizontal and vertical hachuring there is, perhaps, not much to choose, so long as one recognised system is adopted, and so long as some very general rules as regards strength of light and shade, representative of scales of gradient, are fairly well adhered to. We have, after many experiments, finally adopted a sort of combination, the vertical method being applied to inaccessible slopes and precipices, and the horizontal to ordinary hill slopes. This, so far as I can see, is the easiest method of topography to teach, and the quickest learned. In an artist's hands it can of course be rendered artistic, but as a rule, I must confess our field maps are not beautiful. They possess, however, the merit of being fairly intelligible, of not pretending to a higher degree of accuracy than they are worth, and of being readily reproducible. This last is a point of great importance, and is, I think, frequently overlooked.

I feel that no lecture on geographical topography would be complete without some reference to the topographers themselves. I have described very briefly and inefficiently something of the nature of the work which is now included under the general term geographical surveying, and I will only add a few words about the geographical surveyors. It may indeed be a matter of interest to some of you who look forward to a career of foreign service, if I tell you something of the Indian survey system, with the topographical side of which I have been so long connected. It is, to begin with, a civil department, composed of two classes of surveyors, European, or Eurasian, and native. Hitherto the superintendents and higher grade surveyors have been exclusively European; the lower grade of surveyors and explorers have been natives. The Europeans are a miscellaneous collection of Royal Engineers, Indian Staff Corps officers, civilians of the uncovenanted class, and pure Anglo-Indians, men who have been born and bred in India. The natives are hardly less miscellaneous : Hindoos, Mahommedans, Pathans, and Ghurkas, the Bengali Babu and the frontier tribesman—each finds his own place in the survey list. The comprehensive nature of the personnel of the department is well suited to the equally comprehensive nature of the work it is required to perform. From geodetic operations, involving the solution of high scientific problems, to the measuring up of paddy fields, or the impression of the first explorer's footsteps across unknown wastes, there is ample room and opportunity for the employment of all degrees and classes of intelligence, and for testing every variety of physical capacity for endurance. But in all the many branches of its curiously diversified operations, the department is essentially civil. Under the pressure of military or political operations in the field, it has for many years been called on to furnish a contingent for the mapping of the theatre of war, or the area of political discussion, and the work which has thus fallen to its officers to carry through has necessarily been essentially military in character, framed for military purposes, and carried out by military men. Yet the department has no recognised military organisation, nothing analagous to the corps of military topographers which is part of the military system of other European nations, whether you are gathering information in the face of an active enemy, or whether star-gazing within the safe recesses of an observatory, you do not lose your civil character, and your services in either case are those of a civil departmental officer. Within the last five and twenty years, during which time, it may be said, geographical surveying as a special branch of the general science has assumed its distinctive character, the calls for military geographical surveys have been frequent and urgent, and the response to the call has been made under almost all conceivable conditions. But never yet has anything been attempted in the way of systematic geographical surveying, considered as distinct from exploring, beyond our own frontiers, except under the pressure of military or political emergency. Under the able guidance of Colonel Woodthorpe and Major Hobday, of the Bengal Staff Corps, such surveys are now being pushed forward, under comparatively favourable conditions, in Upper Burmah, but, so far as I know, this is only within the limits of territory that we now call our own.

It must be admitted, I think, that under these conditions of sudden demand, the geographical survey parties placed in the field have been occasionally of a somewhat haphazard order. Revenue surveyors have found themselves face to face with geographical problems for the first time; astronomers have been asked to revive their long forgotten reminiscences of field sketching; a party designed for topographical work has formed itself without a single professional topographer belonging to it. For however convenient in theory, in practice it is found impossible for men to be equally proficient in all branches of such a wide range of scientific attainment as a department like that of the survey of India embraces.

Nevertheless, we cannot point to the net results of the geographical work extending over the last quarter of a century with anything but satisfaction. On the whole, indeed, we have fair reason for congratulation, and I most specially desire to point out to you the reasons why, without any special organisation to meet military demands, we have still, on the whole, met them with fairly satisfactory results. The reason lies chiefly in the adaptability of native character to work of this sort. By far the largest proportion of our geographical topography has been secured by natives—indeed, the proportion furnished by European agency is becoming comparatively insignificant. Of the value of natives as explorers I have already spoken. The public view of the subject has been shortly summed up in *The Times*, of the 25th of January, 1888, as follows :—"These men are excellent explorers. They are prompt, ready, and ingenious ; and they have an eye for what is wanted in the way of information; they are able to penetrate in that hostile and suspicious country," referring to Thibet, "where no European could go. The employment of such men is creditable to the Indian Government." Quite so, but it is not only as explorers that natives have been found efficient instruments in the hands of Government. They are most excellent topographers for geographical surveys, and their promptness, readiness of resource, and keenness for distinguishing what information is valuable, are qualities which are all of them very applicable to the art of mapping, even to the smallest details of topography. There is, moreover, never the same difficulty in increasing the native staff that there is as regards the European. The requirements of a native surveyor are comparatively insignificant. He can be readily accommodated and easily fed. His actions involve Government in little or no responsibility. He moves about without escort or baggage to speak of. He asks no inconvenient questions, and is contented with comparatively modest pay; and if, in addition to these advantages, his work is thoroughly trustworthy and accurate, the argument in favour of his employment, almost to the exclusion of European agency, would seem to be unanswerable. But on this point it is necessary to say that opinions are divided, and I am well aware that there are high authorities who think that I place, perhaps, too much faith in the value of native topography. I can only repeat here what I have said elsewhere, viz., that the foundation of truthfulness in the work of natives lies in their scientific training. Moral truthfulness does not, alas, distinguish the Oriental, and where the mental discipline of a long course of scientific education is wanting, there is seldom any real appreciation of the value of accuracy, either in statistics or topography. But our native surveyors undergo this training, and it is ever one of the chief aims of the European officers of the survey department to school beginners into habitual methods of accurate detail work, whether in the form of mathematical computation or of topographical delineation; so that under circumstances where no severe checks can be applied to the work of individuals, that work may yet be accepted as trustworthy. I cannot too strongly impress this upon you, because you who are now learners will soon be teachers. If you wish to have trustworthy results, you must subject natives to the same process of mental (if not moral) culture that you have undergone yourselves. When once you have tested the effects of it, you will very soon perceive that the native has the power of acquiring a kind of patient and persistent determination to record minute detail, which the habitual energy and impatience of the European character frequently denies to the white man. When a native *is* accurate, the minuteness of his accuracy is a marvel. It is this concentrative faculty which, when developed by a long course of careful training, renders the native topographer also a most useful agent for collecting statistical information for military and political purposes. Independently of the fact that he travels further and examines the ground he travels over far more closely than the ordinary traveller, he has acquired the gift of self-dependence in obtaining information. He is far less satisfied with what he hears, and he has the habit of examining pretty closely that which he sees. So that our sub-surveyors, as the native subordinates are called, are also our best intelligencers. There exists, unfortunately, a very well-grounded suspicion of native information, as a rule, in military circles in India, for it has led to many a military fiasco and to much political grief; but the cause of it may, I think, be found chiefly in the want of recognition of this important principle—that habits of scientific accuracy (apart from moral truthfulness) can only be attained by careful and systematic training; and thus too much trust has been given to untrained native authority. It is all-important, I think, that you young officers who intend hereafter to enter on the most interesting field of scientific geography, should stand clear of all popular prejudices as regards the value of native labour. In a hundred different ways you will learn by experience, if you do not believe me now, that the native can do much that you can never hope to do; whilst you may, by duly subordinating your desire for personal adventure, and, perhaps, personal distinction, to the uncongenial duty of infusing your knowledge into others, multiply your own ability, brain power, and energy indefinitely, and so cover vastly more of the world's wide surface than any number of distinguished travellers. I am not referring, as I beg to remind you once again, to India only, or to countries near India. The same principle will apply all the world over, and I look forward with confidence to a considerable development of this imperfectly recognised power of acquiring geographical information in the future.

I will now endeavour, as shortly as I can, to recapitulate the main points of my lecture, in order, as far as possible, to crystallize your ideas on the subject, and I will then ask you to listen to a few words that Mr. Pierce has to say about the solar attachment. First, scientific geographical surveying should be regarded as a distinct branch of the general science, apart from routine surveys of the ordnance class on the one hand, and explorations and reconnaissance on the other. It is based on the well recognised principles of preliminary triangulation by means of accurate alt-azimuth instruments, and subsequent topography on the basis of triangulation. The topography may be on any scale and involve any system of drawing you please. The essential point to remember is that it must fit itself to one comprehensive scheme of triangulation, or it is no longer surveying in the scientific sense of the word. The triangulation may undoubtedly, within certain limits, be purely graphic, carried out with the plane-table; but I have given my reasons to you for insisting that the theodolite is a necessity over large areas, and these reasons may be summed up briefly as follows:—The theodolite record, which is checked, ensures a high degree of final accuracy by assisting in identification of minute features from varied points of view, and, further, these recorded observations are independent of the distance of the object observed, which is not the case with a plane-table of limited size. Again, the theodolite gives the power of check by means of astronomical observations, which are quite indispensable to this class of work. A very frequent condition under which geographical surveys have been carried out by our officers is that of time pressure, and the frequent limitation of opportunities to visit good points for observation. In future, possibly, this condition may not be so constant, but at present there is no organised work of this nature during times of peace and political quiet. Thus the triangulation may be most irregular in its nature, and be compelled to shape itself to very narrow circumstances. It is all the more necessary then that you should study for yourselves what may be effected under these various conditions, and what results may reasonably be expected. In this, the essential foundation and backbone of a good geographical survey, all your energy and much foresight will be necessary. This is the work of the specialist, and can never be reduced to routine methods, worked by rule of thumb. Having secured your triangulation, utilise any and every method available for filling up the detail with as much information as you can trust; using your own common sense as well as scientific checks to decide on what is or is not advisable. Here there is ample room for others besides specialists. Geographical topography in these days is almost synonymous with plane-tabling, and we have now, distributed through the service, a fair sprinkling of active-minded and energetic young officers who are capable of lending great assistance in this respect. But the backbone of your topography will rest on the capabilities of trained subordinates, the educated rank and file, men trained by yourselves, and adapted to the country in which they are to work, whether in Asia or Africa. There is no school of training for geographical work that I know of in India or England, excepting the Indian Survey Department, and that, indeed, only carries topographical education through the ordinary surveying routine. Much will depend on yourselves individually; on your own knowledge of your work and your power of imparting it to others; on your faculty for choosing the right men and estimating their capabilities; and on the success with which you can adapt yourself to native character, and the tact with which you can deal with all classes of people. Do not imagine that you can start off with a plane-table into an unmapped country and bring back with you a scientific geographical survey. That you cannot do. You will doubtless acquire much useful geographical information, but it will not be scientific, and it will not be a survey. I have been careful to adhere, as far as possible, to general principles, without entering at all into many points of detail which would afford interesting matter for discussion. But I feel that these general principles are important as subjects of study for every well educated officer in the service, whether surveyor or not. Details may well be left to the further attention of those who mean to make surveying a speciality, and who anticipate a life of interest in the making of fresh geography.

At the conclusion of Lieut.-Col. Holdich's lecture, Mr. Joseph Pierce, M.A., A.M.I.C.E., gave a short description of the method of plane-tabling used in the American surveys, in which the principal points touched on were as follows :—No attempt is made in the United States to make an absolutely accurate ordnance survey as we have in England ; it being considered sufficient, and advisable on account of the less expense involved, to obtain a topographical survey of the country, in which errors are eliminated only so far as they can be graphically observed. To this end the plane-table is substituted for the theodolite, and is larger and of a more complicated pattern than that used in India. The American plane-table boards are about 24ins. × 30ins., and are fitted with a *ball and socket attachment* for horizontal adjustment, see *Fig.* 1, *Plate* III., and short levels are attached to the *alidade*. This *alidade* is used instead of a sight vane, and consists of a metal straight-edge, to which is fixed a solid column with Y's carrying a telescope, surmounted by a long level and provided with a graduated vertical arc.

Where triangulated points are obtainable, these are laid down to scale on the P.T. sheet ; otherwise two points near the extreme limits of the country to be mapped are marked on the sheet at an assumed distance apart, and a triangulation is constructed, working inwards from these points.

The *field map* is reduced to the required scale in reproduction, and is usually executed at about *twice* the scale of publication. The method of *scaling* maps constructed on *assumed* bases was not indicated by Mr. Pierce. The almost unusual system adopted in contouring is to interpolate the position of the curves between points whose differential heights have been obtained with the alidade, instead of levelling and surveying each particular contour.

Mr. Pierce next described the solar compass, and stated that it was an instrument very much used in the United States for finding the meridian in districts where the magnetic compass is unreliable. The meridian is found, as the name of the instrument implies, by means of the sun, and the principle of the action of the instrument is that an equatorial telescope is not in adjustment unless its base of revolution is in the plane of the Equator, or in other words, makes an angle with the horizon, measured in the plane of the meridian, equal to colatitude.

The form of the instrument is that of a small theodolite, without graduations on either the vertical or horizontal arcs, and having a clamping attachment to the former arc only, see *Fig.* 2, *Plate* III. It is attached for use to the top of the theodolite (or alidade) telescope between the trunnions, and moves with it, its base of revolution being parallel to the plane of the axis of theodolite telescope.

Then, if the solar compass telescope be set at an angle to the theodolite telescope equal to the declination of the sun, and the theodolite telescope at an angle to the horizon equal to the colatitude, the solar compass will only be in adjustment as an equatorial, and consequently follow the course of the sun in the heavens, when the theodolite telescope is in the plane of the equator, and this, as it is set to the colatitude, can only be when it is in the plane of the meridian. If, therefore, after setting the two telescopes, as above, by their vertical arcs, both are turned on their respective base plates until in such a position that the sun travels along and not across the horizontal wires of the solar compass telescope, the theodolite telescope will be in the plane of the meridian.

The manipulation in practice is as follows:—Both instruments being in adjustment. (1) Set the solar compass and theodolite telescopes (both pointed the same way) parallel to each other by levelling each by their respective bubbles, (*Fig.* 3, *Plate* III.). (2) Set the *theodolite* to the declination of the selected limit of the sun (corrected for refraction and parallax) downward for north, upwards for south declination (*vice versa* for south hemisphere) (*Fig.* 4, *Plate* III.). Then level the solar compass (*Fig.* 5, *Plate* III.). The angle between the two telescopes will then be the declination. (3) Set the theodolite to the colatitude of the place upwards (*Fig.* 6, *Plate* III.). (4) Turn both telescopes on their bases until the selected limit of the sun touches and does not move off the horizontal wire of the solar compass; the theodolite telescope will then be in the plane of the meridian.

N.B.—Operation (1) is only necessary with theodolites and alidades that have the bubble attached to the telescope; with instruments of the Grover-Everest pattern it may be omitted.

T. H. H.

PAPER VI.

ON ENTRENCHED CAMPS AND DETACHED FORTS.

BY CAPT. LOUIS JACKSON, R.E.

I.—INTRODUCTORY.

WHEN, towards the close of the 17th century, Vauban systematised the attack of a fortress, and for nearly 200 years after that, the military engineer might congratulate himself that the most important branch of his profession was almost of the nature of an exact science. The well-defined rules for the attack, with the strictly limited capabilities of the arms in use, produced a corresponding definiteness in designs for defence. Siege warfare, like most of the military art of last century, was a matter of formulæ, within the reach of every student. Among many other changes, however, the present generation has seen the art of Vauban (in so far as it could be expressed by rules) swept away. Nowhere has the epoch-making development of war material produced a greater revolution than in fortification. Especially since the last two great wars, every sort of theory has been put forward by writers; diametrically opposite conclusions are often drawn from the same instance. Questions as elementary as the placing or not placing guns in forts are in debate; earth and iron are at deadly feud. In this chaos there is no Vauban to restore order, nor is it probable that any man will ever again have the authority of his magnificent experience.

At the same time, it is very necessary that something should be done towards establishing a firm basis of theory that is required for the new departure in fortification. The fact that a preference has been shown abroad for iron and masonry does not alter the other fact, that the three, perhaps, most typical defences of late years—I mean Sebastopol, Belfort, and Plevna—were made behind field profiles. The latest examples of permanent taught in our own schools are half-breed modifications of old types. Every detail of trace, profile, and armament of model forts recently put forward by the great modern master, Brialmont, appears open to grave debate.

The strategical aspect of the question is also undergoing modifications. Hitherto the defence of States has been chiefly a matter of frontier lines. Now that, on the one hand, strategic points, owing to improvements in communications, have greatly multiplied, while on the other, small places (I do not mean isolated, self-supporting forts) have little power of resistance unless surrounded by a girdle of outworks quite out of proportion to their importance, while lines of communication may be much longer, and extemporised intrenched positions have acquired an enormous importance—it appears that the value of frontier lines as barriers has greatly decreased; and with the increased powers of defence that now belong to large places, chiefly by virtue of the manœuvring power of long-range weapons, the value of these has correspondingly increased.

At a time when all these matters are lying open, if some of the reserve force of the Corps could be brought to bear on them—if something like general discussion could be raised and kept going, much might be done. At present the whole burden is borne by a few experts at Whitehall. We look to them for light and leading, but their time is so much taken up with practical work that they can have little left for pure theory. Yet the theory is more wanted at this moment among us than it has ever been. In the present state of public feeling, the defence of London might possibly get a stage beyond lectures at the Royal United Service Institution; or in India, three intrenched camps for 30,000 men each on the 500 miles of Indus line, with another at Kandahar, would have a very tranquilising effect on the Russian mind. But on what principle should they be built? What system of fortification, and what types of individual works are before the public to-day that are consistent with a reasonable expenditure, and at the same time give fair promise of being efficient against the methods of attack that may be employed twenty years hence? In the matter of cost, we cannot base ourselves on what the French and Germans have done, because, vast as has been their expenditure since 1871, it has been in great part incurred in modifying existing defensive works. The same cause detracts from their value as types. Are we then to follow the Continental text-books, or the ideas of Todleben or Brialmont? If an officer in India, who had not had any Whitehall experience, were suddenly called upon to design a permanent entrenched camp, to what source of information should he go to get his ideas in order? He would most likely consult the works of General Brialmont, and, after consideration, report that neither time nor means would allow of the construction of a belt of forts with enceinte, as there described; finally recommending the adoption of field defences *à la* Plevna. *Enfin*, says Napoleon, *tout ce qui est humain est limité;* a fact which the designers of disappearing cupolas and armoured train-batteries do not seem to recognise.

I have ventured, therefore, to come forward with some views, chiefly in the hope of eliciting valuable criticism. Some apology is due for the haste in which the paper is put together, under pressure of other work; but as my object is to raise questions, not to set them at rest, I may hope for indulgence. The points I attempt to keep in view may be conveniently stated as a confession of faith. I believe—

(1). In economy. This is the corner stone of a good system, because it increases the resources available for men and armament.

(2). In simplicity and unity of defence. By this I mean a system of which the whole force can be exerted at one time, and of which the different parts, defensive and offensive, are designed to fulfil their own function, and no other.

(3). In perfect security of cover. This applies to the garrison; that they should be perfectly protected up to the moment of the assault.

(4). In an indestructible obstacle. Proof, that is to say, against artillery.

(5). In rapidity of construction. That it should be possible to build a fort in something less than seven years; or even three, which is the minimum where there are two or three tiers of masonry.

(6). In giving full scope to the human element of defence. That the system of defence should give opportunity to the defenders to use all their ingenuity, all their local knowledge, and that they should not be cooped in behind multiplied lines of defence as if they were afraid to meet the enemy on any sort of fighting conditions.

(7). In adaptability of design to improvements in weapons.

(8). And finally, and most implicitly, in mother earth.

II.—Entrenched Camps.

There is some debate as to the proper application of the term *entrenched camp*. No doubt a fortress whose main object is to serve as refuge for an army has the best right to the name; but as modern fortresses with detached works are all, from their size, equally capable of receiving an army on occasion, and all of much the same type, it appears allowable, and is decidedly simpler, to class them all as entrenched camps.

The latest types, then, of permanent entrenched camps, both in theory and practice, consist almost always of an enceinte of simple trace intended for guns, a belt of detached forts, and a number of permanent batteries, sometimes between, sometimes in advance of, the forts, and depending on the latter for supplies and protection. In addition to these are the extemporised batteries and the field defences. There are thus three lines of permanent defences. First, the batteries to be silenced, then the forts to be taken by regular siege, and finally, the enceinte, upon which all the remaining guns have been mounted, to be attacked by the same process. It is to be noted that endeavours are always made to shelter the town from bombardment. The minimum distance of bombarding batteries from the forts being taken at about 3,000 yards, and the maximum range (from Krupp's Meppen experiments) at nearly 11,000 yards; the resulting distance of forts from the enceinte is given at from 5,500 to 8,000 yards. In practice the distances are mostly determined by the lie of the ground. Thus, at Paris*, the fort at St. Cyr is 18,000 yards from the enceinte; at Verdun the distances vary from 2,300 to 12,000 yards; at Belfort the new forts are from 4,500 to 11,500 out; at Metz, 2,800 to 4,500; at Strasbourg, 5,200 to 10,000.

The resulting theoretical perimeter, assuming an enceinte about three miles across, and forts distant 7,000 yards from it, is about 60,000 yards. A rough estimate for the garrison, under different formulæ in use abroad, would vary from 33,000 to 55,000 men. Whichever limit we take, it is obvious that these figures, as the standing war garrison of a single fortified place, are not very suitable to the British army; especially when one considers that, owing to the severe fatigues of a siege, the quantity of technical work and the good discipline required, a fair proportion of the troops should be regular and of the best quality. (If the auxiliaries were very poor, I would make this proportion one-half; if very good, never less than one-fourth).

* (These distances are taken from Marga's *Géographie Militaire*, Ed. 1885).

Looking further into the conditions of these places, we find that the forts are of very expensive construction. Double tiers of masonry; a liberal use of iron; costly fittings for lifts, etc.; deep ditches revetted on both sides; numbers of guns; the same repeated on a smaller scale in the batteries; military roads and railways; the enceinte, which, though simple in trace, involves a great deal of solid earthwork; and, perhaps, in addition to all this, armoured trains such as Commandant Mougin proposes, costing £16,000 per battery of three guns, exclusive of the guns and the railway. Even nations expecting a struggle for existence must stop somewhere in their preparations. It is obvious that John Bull, as at present advised, will not undertake to defend himself on this scale.

The question then arises, can the result required, viz., the keeping of the enemy outside the fortress, be secured at a less cost? It may be considered under the following heads:—(*a*) bombardment; (*b*) the necessity of the enceinte; (*c*) the emplacement for guns and the forts.

(*a*). *Bombardment.*—As already noted, the dimensions of model places are calculated on the assumption that the besieger is to be kept out of shelling range of the place. Is this in the first place feasible? Secondly, is it necessary? The increase in the trajectory and power of projectiles progresses at times a good deal faster than the construction of forts. In face of the 20,000 yards range recently attained at Shoeburyness, the 11,000 yards limit seems rather narrow. If it is thought desirable, the heavy pieces of siege trains may very possibly be brought to range up to 14,000 or 15,000 yards in the near future. It is easy enough, then, to provide against a casual bombardment of field batteries, such as the Germans sometimes indulged in in 1870; but when it is remembered that every 1,000 yards added to the distance of the fort-belt adds 6,000 to the perimeter, meaning probably two forts with the corresponding garrison and guns, it seems as if security from serious bombardment might be too expensive.

Now, as to necessity. The objects of the bombardment may be two, viz., moral effect inducing capitulation, or some definite damage such as the destruction of an arsenal. The moral effect, with a determined commandant and plenty of bomb-proof cover, should amount to nothing. (Belfort, Bitsch). A commandant who, having a place well found and fitted, capitulates to a bombardment, should certainly be shot, when available. But if the *morale* of the place, and the lives of the garrison are secure, the loss becomes a purely civil matter, and should not weigh against the military necessities of the case, if it is found that drawing in the forts strengthens the garrison by concentration, and diminishes the expense. That the garrison is so strengthened, within certain limits of reduction, follows from the fact that the smaller the radius of the fort-belt, the greater is the disproportion of distances in favour of the troops manœuvring inside it.

In the case of an arsenal, its preservation is probably the *raison d'être* of the place, and it must, of course, be secured at all cost. But in this case the diameter of the area to be protected will probably not exceed 2,000 yards, and the perimeter and garrison of our model place may be correspondingly decreased.

I hold, therefore, that where no establishments of military importance exist requiring protection, any largely increased expense should not be incurred to prevent bombardment. Ample bomb-proof cover should be provided for the soldiers; the citizens should be compelled in peace time to provide themselves with the same new houses should be built strongly, and as far as possible of non-inflammable materials; a good fire-service should be organised; and finally, the enemy might be invited to waste as many projectiles as he pleased. It is not intended to argue that the inconvenience or material loss caused by bombardment under these circumstances would be of no importance; but rather that, as a mere question of insurance, the value of the extra forts would very likely exceed the loss on damage; while the expenditure on the forts is incurred beforehand, and the bombardment may never take place.

In the case of large places, such as Paris (enceinte about 10,000 by 12,000 yards), the expense of adding a few thousand yards to the already very large perimeter is not important. Also, the increase helps to make blockade impossible. On the other hand, the effect of the besieger's shells must be confined to certain quarters, and he cannot, therefore, expect much result from it.

The following conclusions appear to be justified. In the special cases of very large towns, where important civil interests are concentrated, and a large population has to be kept in order, it is worth while to provide against bombardment. But in the more numerous cases where fortresses are established for military reasons, and where economy is all-important, it is not worth while, and in selecting the positions for detached works, regard should be had solely to the best fighting conditions for guns and garrison.

None of the foregoing remarks, of course, apply to sea-coast towns, whose case is quite different.

(*b*). *The Enceinte.*—Is it permissible to doubt the utility of an enceinte? All the great Powers build them, and nearly all the great writers support them. That there is room for doubt, however, even General Brialmont admits. In his *Camps Retranchés* (1876), after devoting many pages to the proof of the absolute necessity of this line, the last paragraph of the work contains the following curious refutation of his own arguments:—"*La possibilité d'envahir la ville, lorsque la réserve centrale est battue, semble un argument sans réplique, en faveur de l'etablissement d'une enceinte de sûreté; mais, d'une part, cette entreprise offre tant de chances défavorables, et, d'autre part, son influence, en cas de succès, est si peu décisive, qu'il n'y a pas lieu de s'en préoccuper beaucoup. On pourra, du reste, créer au moment de la guerre, sur les points les plus exposés du périmètre de la capitale, des retranchements provisoires, qui tiendront lieu de l'enceinte de sûreté, sans en offrir les inconvénients.*" The case in which he supposes himself able to dispense with his inner line, is that in which he has substituted for a belt of forts groups of works forming small detached entrenched camps, with large gaps between, in which the central reserve is supposed to act, with flanks supported by the camps. There is, however, no reason to suppose that the central reserve would fight better in these gaps than behind the belt of forts; and if the reserve happened to be demoralised, the besieger could walk in. A case in point, at Metz, will be quoted presently.

The disadvantages of the enceinte are patent. Besides the expense, there is the objectionable restriction, and with the modern tendency of towns to spread themselves into suburbs, the impossi bility, under any regulations, of keeping a clear field of fire.

The detached fort was at one time supposed to depend upon the central works for actual fighting support. What that support was worth, at a distance of 3,000 or 4,000 yards, we need not enquire now; but at all events, there was unity in the scheme of defence, and most of the powers of the fortress were by way of acting simultaneously in mutual support. At present that is not the case. As far as the permanent works are concerned, the defence is split up into two distinct lines.

I propose now to examine briefly into the use of the enceinte, in its two main objects: these are (1), as a second line; (2), as security against raids.

(1). The advantage of a second line is that it allows of a defence being prolonged *after* the first line has fallen. Whether the combined defence of first and second line would last longer than that of the first if the whole available strength had been concentrated there, is the pith of the question. The knowledge that there is a secure position to retire to behind the first line does not lead to a protracted or stubborn defence of the latter. On the contrary, it rather tends to relax men's minds, and their hold of the first object, thus urging them to the first fatal step down hill, which is the beginning of the end in sieges. Besides this, the forces are deliberately disposed so as to be beaten in detail. The besieger brings his whole force of men and guns against half the defender's force in the forts, and having beaten them, against the demoralised second half in the enceinte; whereas if the defender's whole force had been in front line together, they might have maintained their ground successfully. The common sense of the question seems to be this: if you do not think your line strong enough to meet the enemy's probable force, strengthen it; do not throw away your means by placing the extra guns where their effectiveness is enormously diminished, namely, on ramparts, and the whole additional force, whether of obstacle, guns, or men, by placing it where it can take no part in the fight till the battle is more than half lost. The fact is, that the whole pernicious system of second lines is a relic of the time when the defence was no match for the attack, and when the attack was methodical, advancing from successive parallels, through successive breaches, to the regulation end. Engineers then thought that if they could not avert the end, they would at least delay it by multiplying lines of defence. But the containing power of the breech-loader has altered all that. "*Place assiégée, place prise*," is as obsolete as Brown Bess, and the true *rôle* of the defence now is to meet the assailant from a footing of superiority, and repel him at all points.

(2). The enceinte as security. If a besieger arrives before a line of detached forts, the intervals well flanked and swept by guns, and a field force manœuvring between, is he likely, however dashing, to attempt a *coup de main* on the place itself? In civilised warfare, I say, certainly not. Such a proceeding, whether by day or night, or under cover of fog, could only result in disaster to the force that thrust itself into the net. It is convenient here to refer again to General Brialmont's argument, in his "*Fort^n. du temps présent*," as he makes great capital out of the cases of Metz and Paris in asserting the necessity of the enceinte. He says (vol. 1, p. 54), that if those entrenched camps had had no fortified centre, there is every reason to believe that the Prussians, after the battles of Gravelotte and Chatillon, would have forced the beaten armies to capitulate or retreat. This assertion, as regards Paris, is founded on the statement of General de Villenoisy, that "everybody" who was in Paris in 1870 was agreed that without the enceinte the Prussians would have had no difficulty in entering the town—that the forts alone could not have stopped them. Assuming "everybody's" opinion to have been correct, this points simply to the fact that the forts were not sufficiently numerous, or not well enough placed, to defend the whole of the line which they occupied.

At Metz, we are told, if the enceinte had not existed, the French army would have been pursued beyond the forts, and probably destroyed. This is because Von Goetze says that on the 17th August, after the bombardment of the unfinished forts of Queuleu and des Bottes, they could probably have been stormed successfully; but that if this had been done, they could not have been held, for want of communications, against the efforts the French would certainly have made to retake them. The criticism which General Brialmont founds upon this statement of possibilities appears to be perfectly unjustifiable. In the first place, supposing there had been no enceinte, and that those two forts had been stormed: Bazaine's army would then have been fighting behind hasty entrenchments, with both flanks secured; the Germans, attacking on a very narrow front, with their flanks, and even their centre, under the fire of forts St. Julien and St. Privat. Under these circumstances it is impossible to conceive that the French, however demoralised, could have been beaten, or that the Germans could have been reckless enough to attack. Secondly, what was suggested as possible to have taken place was not the attack of the central force, but of the two forts, and it was not the enceinte that prevented this, but the want of communications, and the fear, presumably, of the neighbouring works. Thirdly, the only moral of the whole story appears to be that it is as well to have your forts finished before the arrival of the enemy. For if the possibly unprepared state of a line of detached forts is to be accepted as proof of the necessity of an inner line, one might as well argue that a possible omission of part of the enceinte makes it unsafe to rely on fortresses at all, and therefore foolish to build them.

Putting aside arguments from special cases, which are always unprofitable, it is difficult in a small space to review all the chances for and against the success of a force making a raid on a place through the intervals of the outer line. I do not believe, however, that any leader would accept the risk; both because, if that line were properly organised, success *ought* to be impossible, and because, as said in the paragraph quoted above, it would be, if attained, "*si peu décisive.*"

But, it may be said, suppose a gap occurs in the line; suppose one of the forts is lost by accident or treachery. Why then it would probably be shortly regained; if it were properly supported from both flanks, the enemy could do little with it for want of communications, and would not be apt to hold on to it very seriously. The worst that he could do would be to turn its flank guns against the neighbouring forts. In the resulting artillery duel the defenders would most likely have the advantage, being more familiar with the weapons and the ground. It might be worth while in this connection to make it impossible for the casemated flank guns, if any, to be trained exactly on the casemates of neighbouring forts; but for general fire on the remainder of a work, collateral support would be invaluable. The besieger having gained possession of a fort and endeavouring to hold it against counter-attack, would be enfiladed on the gorge parapet from both flanks up to the last moment, with most disastrous effect on his troops.

If two neighbouring works were to fall in the same way, the position would be, to a certain extent, the same; the front of each and the outer flank would be under fire, and it would hardly be possible to hold on to them until the necessary communications were established.

If then a belt of forts may be considered as proof against assault, and against the limit which it is fair to assume of accident, what becomes of the enceinte as security? The conclusion at which I have long since arrived is that the enceinte is a useless expense, an incumbrance, and even a drawback to the defence.

It will be understood that the foregoing arguments are based on the conditions of civilised warfare. In designing an entrenched camp, say, for Kandahar, I should add an enceinte as a matter of course, to keep out the Tartar horseman, who does not always stop to calculate decisive results; and also to keep in check the civil population.

(*c*) *The Emplacement for Guns, and the Forts.*—It will be sufficient for the purpose of this section to say that the whole tendency of modern designers seems to be towards excessive costliness. As long as guns are placed in forts or in fixed intermediate positions, their protection must be costly. Iron and masonry equal to the assault of existing artillery is already so expensive that it cannot be used except in the most important works; and the cupola school thought that the last word had been spoken when they made allowance for a 9-inch gun as the heaviest that could be used in land sieges. But the experiments of the last year or two must have brought home to them the fact that in face of new explosives and pneumatic guns they are as far as ever from the goal of complete protection. The mistake they have made is in meeting the attack where it is strongest. To meet the force of artillery with force, is an expensive, and so far a losing game. The powers of big guns increase according to the demands made on them, but the human element behind them remains always the same. Training may do much for the gunner, but it will not enable him to prophesy. Match yourself against the gunner, therefore, and not against his weapon: baffle the enemy rather than defy him.

If means can be found to fight the guns of a fortress effectively without placing them in fixed positions, it follows that a great economy will be effected in the forts. It remains to be seen whether any further economy is possible in their trace and profile.

To sum up this section, I believe that economy is to be effected in the model entrenched camp, (1) by omitting the enceinte; (2) by reducing the perimeter (except in special cases); (3) by cheapening the forts. The method of fighting the guns outside the forts, and the type of forts, will be considered in the next two sections.

III.—The Artillery.

Assuming for purposes of discussion the armament of our type place as 1,000 guns, it is obvious that the right employment of such a mass of artillery is a matter of greater importance than any questions of trace or profile. It being thoroughly understood that the siege cannot begin seriously until the artillery of the defence is silenced, much attention is now directed to the emplacement of guns. Unfortunately, the service data that we have to go upon in this case are very poor. The Franco-German war offers very little example, and the Russo-Turkish practically none, of the way we may expect to see artillery used in any future war of siege. In the former case rifled guns were not much more than ten years old, and were not to be compared to the present weapons. Also, it was possible to work the attacking batteries in a manner that should be out of the question now, owing to the inferior armament of most of the French fortresses, and the way the guns were exposed on old-fashioned ramparts. We must, therefore, fall back on the peace performances of modern guns, and apply them with deductions to the conditions of war.

The recognised methods of working the guns of the defence (not counting field batteries manœuvring in the open, or mortars) may be classed as five, viz., (*a*) under iron protection; (*b*) on the rampart of forts or enceinte, with or without disappearing arrangements; or in permanent auxiliary batteries, which is the same thing in principle; (*c*) in unseen and variable positions connected with the forts, as in the ditches or covered ways; (*d*) in extemporised siege batteries; and (*e*) on a circular railway, behind a screen or in armoured carriages.

(*a*). *The Iron Battery.*—So much has been written for and against the employment of iron, that there are probably few officers who have not by this time drawn their own conclusions from the various arguments put forward. The first point to be considered is:—For a given expenditure, will the number of guns that can be mounted in turrets have the same offensive power as the number that can be mounted behind a parapet? Opinion here is at fault for want of practical guidance. General Brialmont, taking a fort adapted for an armament of 35 guns, believes that six guns in turrets would, thanks to their protection, be as efficient as the 35, thus estimating one turret-gun as about equal to six rampart guns. On the other hand, the author of *Studies in Fortress Warfare*, translated for the *Corps Papers* by Major Clarke, lays down that four extra siege guns are required to deal with one shielded gun. If both these valuations were taken as correct, it would follow that four guns in siege batteries were equal to six rampart guns, a conclusion that would have been inside the truth in the days of bastions and ravelins, but ought not to hold now. Again, the report on the Bucharest trials, by Majors O'Callaghan and Clarke, states that the cost of the French two-gun turret, without its armament, would have provided six heavier overbank guns; or, including the armament, there might have been four overbank guns of greater power for each one of the turret guns. If the estimation quoted above, of six to one, is right, this leaves a margin of economy in favour of the turret, but only as against rampart mounting. This kind of valuation, however, depending wholly on opinion and prejudice, is highly unsatisfactory. Of course, if it is to be assumed that the 36 half-protected guns will be put out of action in a couple of days, and that the six shielded guns will remain in action for an indefinite time, the advantage will remain with the latter without further argument; but even then it would be doubtful whether so small a number of guns, however efficient, would be able to keep the siege works in check. To meet this difficulty the latest idea of the iron school is to fill the redoubts with the new shielded ball mortar; but this does not move the discussion from the old ground. Is the mortar worth its emplacement? The expense of the Mougin turret, tried at Chalons last month, was probably not far short of £15,000. Would the effect produced by a couple of 6-inch guns, even supposing they could be kept in action during the whole of a long siege, be worth this? Is this system feasible? Three such turrets, say £45,000 per fort. For 15 forts, £675,000, exclusive of a large number of mortar towers, and the whole cost of the forts. It is obvious at first sight that the system cannot be carried out in its entirety; would it, therefore, be of any use to attempt to carry it out in part? The more practical question remains behind, whether it is not possible to find a cheaper system by which the guns may be worked as long as required. I shall endeavour presently to show that it is.

Putting aside questions of cost, will the turrets do what is required of them, namely, defy successfully the heaviest artillery that the besieger can bring up? Let us allow that weight of metal, compound plates, and the hitherto successful Schumann shape of dome, will make them fairly proof against battering. Other dangers remain. The concrete glacis and glacis plate might be damaged to an extent that would hamper the mechanism. Again, a certain number of first-class guns would certainly be told off to lay on the port and watch for its appearance. Whether the turret revolved or disappeared, so heavy a mass would move slowly and give ample time for a 6-inch shell to cross an interval of 3,000 or 4,000 yards. The first shot that strikes the mark, knocks the chase off the gun.

One of the most formidable opponents that the turret gun will have to reckon with will be the quick-firing gun. What the torpedo boat is to the ironclad, the 3-pounder quick firing gun in the outposts is to the turret. Its constant stream of steel shells, any one of which striking on the chase will suffice to disable a 6-inch gun, may be expected to do great things in keeping down the fire of turrets.

Nothing has been said yet on this head about the recent Chalons trials with melinite; though if all had been true that the *Times* telegram of the 5th May stated about them, they should have been quoted first, being as conclusive as "*Premièrement il n'y a pas de cloches;*" but from what little can be gathered out of other newspaper accounts, it seems that the effect of the melinite was greatly overstated, and that the new Mongin turret, after prolonged battering, was still able to give fire and shelter its gunners. From such meagre data as we have, no conclusions can be drawn. The trials, however, seem to have been a step in the new direction of attack on turrets, utilising the power of the explosive instead of that of the shell. It is here, I believe, that the real solution of the question of iron defences lies. Place a perfected dynamite gun within range of a cupola, and its days of happy usefulness are numbered.

One drawback to the efficiency of a small number of guns in fixed positions is, that it would almost always be possible to find sites not merely invisible, but protected from some of them. Also, however powerful they may be, they can hardly at one time reply to the guns of the attack, support the advanced infantry, and prevent the construction of siege works. Oh! but, they say, we have large quantities of protected mortars for these objects. This is schoolboy talk. Montalembert, in the same way, proposed to sweep his enemy off the field by the fire of triple tiers of casemates. They told him that his masonry was exposed. I don't care, said he, I will have so many guns that the enemy shall not be able to show himself. *C'est magnifique mais*———.

In trying to defy the artillery of the attack by brute strength of metal protection, the upholders of the iron system have entered fairly on the same interminable contest as that of the big gun and the ironclad. But there is this serious difference between the cases: the ironclad may expect to escape a large proportion of the shell aimed at it—the turret will be subjected to accurate fire; the ironclad has nothing to fear at long ranges from the light guns—the turret, everything.

Upon the whole, I object almost unconditionally to the use of iron for land forts. The great expense of the system will always prevent its being carried out in its entirety. If it is carried out partially, too much reliance will be placed on the armoured guns, and inadequate provision made for the rest. Entire protection can never be assured; and, finally, though one turret gun may be equal in fighting power to half a dozen rampart guns perched like sparrows on a housetop, it will not be better than—perhaps not so good as—one gun well fought from an unseen position.

(*b*). *Guns on Rampart of Forts, or in Wing or Permanent intermediate Batteries.*—This being the simplest and most general case of guns in fixed position, it will be convenient to consider here some of the relations of the artillery in attack and defence. First, as to numbers. The number of guns which the besieger can bring up and keep supplied is strictly limited by questions of transport. This difficulty does not touch the defence, which can accumulate in peace time as many guns as are thought necessary. The guns, however, of the siege train may be of the latest pattern, while those of the fortress will vary from old to comparatively new. These ideas are clearly set forth in the *Studies of Fortress Warfare*, where it is laid down as a conclusion that the besieger cannot expect to have the superiority in artillery. Another point in which the attack has lost superiority is in the relative spread of the batteries. Owing to the large perimeter of the fort line, the attack and defence may now work practically on parallel lines, instead of the siege batteries being able to surround the fortress, and pour in a convergent fire from all sides. On the other hand, the besieger's supply of ammunition is inexhaustible, while the defender may be obliged to husband his; although, with ordinary foresight, this is not a necessary condition. So far, then, as the rigid conditions are concerned, there is nothing that assures the advantage to the besieger. The defender is not even limited to the number of guns that can be brought into line upon the forts and between them, as laid down in the *Fortification du Temps Present;* as if artillery can fire over the heads of their own advancing infantry, they may equally fire over their own batteries, at intervals, allowing for shells breaking up in the bore. If the assailant, then, is to have any advantages, they must be given to him by the scheme of defence. The defence has hitherto shown a generous willingness to provide them. With artillery, knowledge is power. If the enemy knows where your guns are, he can hit them sooner or later. If he does not know, he is helpless, and may become demoralized. Prince Hohenlohe (18th letter on artillery), says: "I have a lively recollection how unpleasant some of the enemy's guns were to us at the siege of Paris; they were posted so entirely under cover that we could not see them, and thus remained long in doubt in what direction, and with what elevation, we were to reply to their fire." Now, the position of a permanent fort or battery is laid down exactly on the map. Whether the enemy can see it or not, he knows its range from his batteries. If he can push forward his outposts till they see it and can observe the effect of shells, he has all he wants. The like information he is careful to refuse to the defender, by placing his batteries in unseen positions, which, in almost any country, can be found within modern effective ranges. It is worth while here to quote an opinion on the employment on service of fire from concealed positions.

Captain Ed. Thiers, of the French Engineers, in a detailed description of the defence of Belfort, at which he assisted (*"l'Artillerie rayée et la défense des places."* Paris, 1874), says, in reference to the withdrawing the pieces from the ramparts and placing them in the ditches, in the open places of the town, etc., "*La longue expérience de Belfort prouve qu'avec des plateforms convenablement agencées, et un bon système de points de repère, ce tir indirect ainsi dirigé est susceptible d'une justice égale à celle du tir ordinaire direct.*" With this valuable testimony, added to the remark of Prince Hohenlohe quoted above, and the peace experiments of late years, it is unnecessary to go more fully into the proof of the value of indirect fire against objects of known positions. Against objects of unknown positions, its value is at least as great as that of batteries placed for direct fire.

Now, in pursuing this problem of the right employment of fire, this is what has to be borne in mind. Besieger and besieged are separated by a zone of neutral ground, denied to either till the fire of the other is silenced. The besieger wants to cross this zone, the defender does not. This is the key of the situation. If the defender can bring about a double check, he has enough. Now, it appears that under existing conditions this is precisely the position that can be brought about and indefinitely prolonged by the use of indirect fire on both sides.

If we take the case of a fort-belt on a large level plain, where both the forts and the attacking batteries can be plainly seen, and the defending guns are in the forts or in permanent positions, the forts have certain advantages over the batteries. These are :—stronger parapets, better gun platforms and traverses, better cover, safer arrangements for the storage and conveyance of ammunition, a slightly plunging fire, better knowledge of the ground. The assailant's advantages are :—some concentration of fire, a better mark, the power of selecting his siege train according to its requirements. Under these circumstances, if the fortress is properly found and manned, the victory in the artillery duel might perhaps remain with it, though at a heavy cost in guns and men. If the defender had concealed his guns, the victory would have been his with certainty, and with infinitely less loss.

Taking the more frequent case of a fort-belt having unseen space in front of it, within range, then, if the besieged opposes batteries in fixed positions to others in uncertain positions, what can he expect but to have his armament gradually destroyed without possibility of effective reply? However excellent the design of the forts, the besieger's progress, though it may be slow, will be sure; while the defender's fire, from its uncertainty, will not only be ineffective, but disheartening to a degree that will certainly affect the tone of the troops.

But in the same case, if both sides employ the concealed battery, what will happen? We may expect the artillery fight to go on indefinitely without any decisive results being reached. This is the state of things that exactly suits the defender. It is the maintenance of the *status quo*. With a mobile system of artillery, the loss of an occasional gun or detachment from a chance shot will be of no importance. Often it will not even be necessary to reply to the siege batteries, and guns will always be available to defeat any attempt on the neutral ground. Yet the assailant can do nothing to bring matters to a head. The attempt to draw in his batteries on to the seen ground would be useless and fatal. The result must be a dead lock, ending in a blockade.

Still, the author of *Studies in Fortress Warfare*, evidently a high authority, is of opinion, with most of the other authorities, that the fort is the "natural place" for the guns. Why? Only two reasons are adduced that are really valid, viz., that the fort gives safety, and that the supply arrangements are better. As to the safety, it might be urged that if the storm-proof fort is stormed, as will sometimes happen, the guns are lost with it; but the danger outside the forts is not real. No troops would attempt to raid through the intervals in daylight for the chance of spiking a few guns, and at night, with proper facilities for locomotion, which is the essence of a system of unseen batteries, the guns could all be moved to places of safety. The convenience of supply is a more important matter; but it is purchased at too heavy a price by the loss of guns and gunners from exposure in known positions to high angle fire. That it is not indispensable is shown by the fact that the attack can do without it.

Taking all these things into consideration, I am very strongly of opinion that the place for guns (except for flanking) is outside the forts. But I should like more light. The subject is of the very highest importance, bearing on field as well as permanent work, and it is to be hoped that a discussion can be raised which will elicit the opinion of the Corps.

(*c*). *Guns in unseen positions about the forts, in ditches, covered ways, inner terrepleins, etc.*—This system has the sanction of General

Todleben, among others. It is a compromise between the systems of fixed and unknown positions, without the advantages of either.

(*d*) *Extemporised batteries.* Provided the site is well chosen, etc., the only objection to these is that all work which is left to be done at the last moment is a dead weight on the defence, and there is always the risk that an accumulation of such work may make the defence impossible.

(*e*) *The circular railway.* At first sight this appears to be the solution of the question of the unseen battery. Guns moving on a railway behind a screen have the advantages of mobility and concealment, the former, of course, in the highest degree. I believe, however, that it will be found to be only a step in the right direction. The concealment is hardly sufficient, since the enemy will have the position of the railway on plan, and if he can get the smoke before it has dispersed much, will have the position of the gun pretty accurately. The line could not be used for locomotion, as it would constantly be blocked by the batteries in action. Also, the repeated shock of firing would probably cause the sleepers to shift, requiring constant packing, and the amount of fire that would be attracted towards the line would cause many small damages requiring frequent repairs. The guns would be much hampered by the repairs, and the working parties would most likely suffer heavily.

As to the armoured train, its expense has already been noticed. It is very carefully and elaborately worked out; but the protection is more than is required against shrapnel, and if struck by a heavy common shell, it seems likely that it would be thrown off the line altogether, blocking it for hours. Also, it is a much larger target and easier to hit than the gun.

Having ventured to criticise the existing systems of emplacement, it remains to propose what I believe to be the only system possible for the immediate future.

It is, briefly, this :—To have a large number of alternative emplacements for the guns, placed in communication with the circular railway, and at varying distances from it. These positions must be hidden from the attack, either by the lie of the ground, by bushes, or by glacis screens. Each position will be for four guns, the four guns being combined under one command, and acting together as a battery under the superior orders of the officer commanding the artillery of that section ; the section being conveniently taken as the space between two forts. The guns to be on travelling carriages, so as to be easily moved from one position to another, or to the railway. If exposed to high angle fire only, the positions to consist of simple platforms. If vulnerable by direct fire, they will have parapets; but in neither case any traverses. Space permitting, the platforms should be 30 or 40 feet apart. The positions will be in groups of two or three, connected with each other and with the railway by a single road. Each will have a distinguishing number, and be shown accurately on the map. Taking the interval between two forts as 3,000 yards, and assuming that it was proposed to fight 100 guns in that interval, the guns being in batteries of four, we should have twenty-five groups to provide for, giving each battery a group, (this would be a convenient arrangement, but might of course be departed from at will). Then each group would have a frontal space of 120 yards at disposal, and a depth varying according to the distance it was found convenient to make the furthest position from the railway. This disposition, however, would naturally have to be modified if the ground was much broken.

At the commencement of a day's firing, the battery would take position on a set of platforms. If possible they would remain there all day. If the fire became too hot, they would move to another position; if necessary, a group might be evacuated altogether. A certain number would be provided of light steel shields, proof against shrapnel, which could be fitted to the gun carriages. Of an occasional common shell the gun and detachment would have to take their chance.

The firing would be mainly directed by telegraph from the forts or the advanced infantry positions. The whole of the ground within range would be laid out on the map with squares. The letter and number of the square to be attacked being given to the commander of the battery, he would note on plan its range and bearing from his position, and give fire, subject to the observation of the fort.

The railway would require to have two lines to allow of free traffic in both directions, and should be supplemented by a road Steam is not a suitable motive power, as it would advertise the presence of the train. The guns could, perhaps, be best transported on low platforms hung between trucks as low as possible to the rails. The ammunition I would place in metal cases at the foot of the interior slope, if any; if not, behind suitable cover. For conveyance on the railway I would place it on low trucks, protected by a light dome-shaped steel cover.

The cost of this system, compared with others, would not be great. The circular railway would be required in any case, though perhaps, only one line; also the road. There would then be the platforms, a certain amount of parapet, and the plantations, and enough special rolling stock on the railways to deal with almost all the guns at one time.

The majority of the guns would be retired at night, not to waste their fire, but a few kept up for special purposes might be taken for protection near the forts or in rear of the intermediate infantry redoubt.

The great enemy of the unseen system of defence is the balloon. It is possible, however, that to do any effective observation the balloon would have to come within range of the defenders' howitzers. Then notwithstanding Major Elsdale's ingenious plan of shifting the elevation of the balloon to baffle the range-finder, it seems likely that salvo firing by half-a-dozen howitzers at various ranges would eventually bring down the balloon.

Among other devices to mislead the enemy concerning the position of the batteries, use might be made of dummy batteries. Place a man in a protected position with materials to produce a smoke and explosion every quarter of an hour; this would give the besiegers opportunity to throw away a few shells. This plan should be especially followed if the position of a battery had been discovered, and it was found necessary to withdraw it; the enemy being thus induced to continue his fire after the object was withdrawn.

Nothing has been said about disappearing guns with overhead shields, because the principle is applicable in different degrees to any position for guns, whether in forts or outside them. At the same time, I object to an expensive pit on the same ground as I do to a turret. But if the searching power of shrapnel is largely employed by the besieger, some form of light overhead cover will no doubt be necessary. Perhaps a horizontal rope mantlet, rigged like a tent on special standards and carried about with the gun might answer.

Recurring to the question of supply for these moveable batteries, it does not appear to present very great difficulties. At first sight it seems as if there would be a large quantity of ammunition constantly being moved about the positions; but it would be in small instalments, and if an occasional truck load of powder was found out by a shell and exploded, the effect would not be disastrous. If the truck was hauled with a long rope, the loss would be confined to the powder and the truck. Small expense magazines would be constructed in suitable places near the artillery positions. The besieger has to supply his batteries in the open without the advantages of rail and road enjoyed by the defender, and we do not hear of it as being a specially dangerous operation. Moreover, there is a most important advantage in the great diminution of the supplies required for the forts. The supply of the forts might be made a most dangerous operation if the enemy took any trouble about it. He knows exactly where the entrance to the fort is, and can amuse himself by keeping up a constant fire on it if he likes.

A very important point, which has not yet been noticed, in connection with this proposed employment of guns, is that it permits of a very large reduction in the artillery, both guns and gunners, of the fortress. Guns that are mounted in forts and permanent batteries are to a certain extent immobilised. In an entrenched camp of large perimeter the guns of about two-thirds of the works would have nothing to do. At the same time, their removal to the point attacked, and the preparation of positions for them, is a matter of much time and labour. But on the railway and platform system it is perfectly easy to concentrate the whole of the guns of the fortress on any required frontage. On special occasions, by sacrificing for a time the alternative positions for batteries, they may even be fought in three or four lines. When required elsewhere they can be as easily removed. The result of this is that no part of the armament, except the flanking guns of the forts, need be left idle ; and instead of tne extravagant total of 1,000 to 1,500 guns now laid down for a first-class fortress, probably half their number would suffice, and yet tne artillery defence be more powerful.

Before leaving the subject of artillery, let us return to the general question of the employment of guns in forts as apparently intended abroad. Plans of French and German forts show front faces, cavaliers, or low retired parapets, organised with traverses for the use of unblinded guns. The same system obtains in Austria. Assuming that it is intended to work the gun under these conditions, it is instructive to consider the following experiments by Krupp :— In 1882, at Meppen, firing with his 21 c.m. rifled mortar at a rectangle 165yds. by 110yds., range 3,500yds., elevation 36 degrees, weight of shrapnel shell 200lbs., he put 1,439 bullets (of about 2oz. each) into the rectangle in five rounds. Five rounds of the same shell, containing 1oz. bullets, range 2,100yds., elevation 33 degrees, at a rectangle 110yds. × 90yds., gave 1,136 hits.

Five more rounds of shrapnel with 1oz. bullets, at the same target and distance, elevation varying from 33 degrees to 45 degrees, gave 3,831 hits.

The larger target about represents the space inside crest line of a small fort. What then would be the chance, or indeed the possibility of, working guns on platforms exposed to such a fire as this? Of what use are traverses, or even parapets, against high angle shrapnel fire? The traverse may serve to localise an occasional burst of a common shell, but it will also be the cause of the explosion of others, which might have been harmless, and there should be no question of enfilade in the face of a detached fort. Again, pits with vertical sides give little protection against shrapnel. If it is proposed to supplement the traverse or gun pits by light steel shields, they will serve against shrapnel, but may soon be demolished by common shell preparing the way for shrapnel. And this can be done without its being necessary for the attacking battery to see its object. We are then forced to the conclusion that forts, organised as shown in the foreign text-books, with rampart guns and traverses, will not be able to make any headway against an assailant making a scientific use of unseen batteries. Text-books and War Offices are, in the nature of things, conservative; it requires a Gustavus or a Frederick, combining power with perception, to carry out a new idea. We shall, therefore, see gun terrepleins and traverses taught for many years yet; but there can be no doubt that the Power that first lays itself out for the systematic employment of hidden guns will make a revolution in siege warfare.

As I have already said, the same reasoning that condemns the use of guns in forts, applies equally to permanent intermediate batteries. As for wing batteries, they appear to be placed simply with a view to catch ill-aimed shells intended for the forts.

I have already, at the end of sub-head (*b*) of this section, made an exception in favour of the employment of flanking guns in forts. The reasons for this exception are two:—first, that it is necessary, in order that the interval may be effectively flanked, that the guns for that purpose should be in the line, and being there, they are safest in the forts and generally best placed; second, that the conditions under which they will fight make their position less dangerous than that of guns replying to the siege batteries.

If, indeed, it were a question merely of repelling assault on the work itself, I would dispense with flank guns, using only machine guns to assist the infantry. They would be worked from a parapet without traverse or parados, and kept under cover until required. Since the enemy's artillery fire would have to be stopped before his infantry came up to the fort line, and since his infantry fire from the front at close range would be point-blank, the flank would require protection neither from overhead nor from enfilade fire during the time it was defending itself, and would only be concerned with the frontal fire of the infantry attacking it.

The case, however (presumably a rare one), in which flanking guns would be employed, and would be exposed to danger from the distant artillery, would be that in which the intervals were being attacked but not the forts. In this case, as the besieger's infantry would be some distance from the forts, their guns could keep on the forts all the time. Would it then be possible to work the flank guns without complete protection? I think so, though with heavy loss. It is to be remembered that the attack could not be of very long duration, as under such circumstances it could not maintain itself for any length of time in a doubtful situation. The battery would, however, occupy a small space, and though shrapnel would be dangerous, it is not every common shell that gets home at a very long range and with high elevation. With good luck, not many would fall in the battery, in the space of an hour or so during which the guns might be engaged. But as fire would be concentrated on the fort from all possible quarters, they would be exposed partly in rear as well as in flank. I would, therefore, in this instance, use both traverse and parados against fire at low angles and howitzer common shell; and for protection against shrapnel, light steel overhead shields fixed to the gun carriages. Instead of several small traverses, I should employ one large cavalier traverse about twenty feet above the battery, beneath which the guns and men would find a secure shelter when not in action. Under these circumstances the flank guns should be able, with some losses, to maintain their fire.

In the flank also the use of iron may be perhaps permissible. It might be of advantage to have a couple of 6-inch guns, if protection can be got cheaply, to fire on the first visible siege works or other important object. It would be more easy to keep the forts in fighting trim than to make sure of having the organisation of the outside guns always ready for immediate action, and therefore there might be something gained by having a couple of first-class guns in each flank of a fort ready to fire on the front of the neighbouring forts. In the flanks, because protection would be easy and cheap compared with a frontal battery. The design given on *Plate* I. for a detached fort contains an iron shielded casemate for two guns in front of the high flank traverse. I have added this, not because I advocate the use of the guns in this position, but to show what I consider the only case in which iron might be employed in these forts. The shield, being of simple form, would be cheap. Being exposed to blows only at an angle of 45 degrees, at a range of 5,000 or 6,000 yards (say from 3,000 yards in front of neighbouring fort) or finer angles at less range, it need not be strong; a few inches of wrought iron would suffice. The overhead cover consists of 14 or 15 feet of earth, carried by iron girders and plates. This mode of supporting earth protection has the great advantage that if a girder is buckled by a blow, it can easily be supported by passing bars underneath and bolting them to the neighbouring girders. If a plate is broken, it can be replaced by bolting another one to the under sides of the flanges of the girders.

Before leaving the subject of artillery, I should like to say something to raise a question of its general employment. This is a broad one, and belongs, of course, to artillerymen, but it is closely related to the subject of fortification. It is usually laid down, and carried out in practice, that as soon as the attacking batteries open fire, the fortress batteries must reply and keep up the contest as long as they are able. I do not propose to offer any definite opinion on the subject, but is this necessary? May not the fortress batteries choose their own time for action? Suppose the forts are not of a type to suffer much from artillery fire, and that the guns on both sides are concealed, what has the defender to gain by precipitately opening fire on batteries which he cannot see and which are not doing him any particular harm? Or, again, suppose on both sides they are visible, what do the defending guns gain by opening fire, rather than effacing themselves? Here is a case very much in point, from Plevna.

On the 7th September (see Greene's account) firing commenced from the siege batteries at the big Grivitza redoubt. It took all day and all the 8th, though the firing appeared reasonably accurate, to silence the redoubt, "the losses on the Russian side (and probably on the Turkish also) being next to nothing." On the 9th, Grivitza being silent, "the Roumanians made a reconnaissance towards it, but were promptly beaten back by a murderous infantry fire."

Now, what was the use of the Grivitza guns entering on a contest with a superior force in which they were bound to be beaten? If they had quietly withdrawn at that time, they could have done much better by distracting the attention of the Russian guns, when the latter were preparing for the attack, by shelling the redoubts; or by reserving themselves till the infantry attack was developed, the might have done some damage. It seems as if it were a point of honour with artillery to allow itself to be drawn at any time. The case is parallel with that of the artillery duel at a siege, and it is one which would be the better for a great deal of discussion.

IV.—The Detached Fort.

What is a fort? A storm-free enclosure, some one may say, providing shelter more or less secure for men and materials. But what is storm-free? So barbarous an adjective ought to have a definite meaning to justify its existence. If anything, it means that a defensive position, as long as its essential conditions are unaltered, is proof against assault by any number of men with such portable aids to the attack as they can bring across several hundred yards of open ground. If this definition is accepted, the Plevna redoubts were storm-free, while those of Kars, which had a stronger profile, were not. Then, wherein does storm-freedom lie: in the passive or active defence? Apparently in either element if it is sufficiently developed; or in the combination of both. A certain combination or proportion of obstacle and fire defence is familiar to us all as the permanent profile of our youth, with escarp, counterscarp, exterior slope, flank defence, and all complete; administered with but slight modifications to the youth of the rising generation. When these proportions were worked out, the relative powers of man and musket were known from many years of practical experience; in our day, man's power of climbing a wall has not increased, but the musket's power of stopping the man has increased indefinitely, producing such a modification of the problem that we are justified in enquiring whether some more economy and simplicity cannot be gained in taking full advantage of our fire arms.

Again, what is the function of a fort: attack or defence, or both? Certainly the first object of the fort is defence, and it can only lend itself to the attack by giving shelter to the offensive weapon, the gun. This is to admit a confusion of objects, which, as two separate ends can seldom be obtained in the best way by precisely the same means, must lead to a compromise to the disadvantage of both forts and guns. It follows from this that to get the most out of the forts, they should be planned and placed in the manner best suited for defence, and that the guns, other things (economy, security, etc.) being equal, should only be placed in the forts if the best fighting conditions were thus secured

Some considerations have already been advanced on the best way of fighting the guns of the defence ; let us now consider the conditions that a good fort should fulfil.

The object of a fort is to form, in connection with others, an impassable barrier. Behind this barrier and between its intervals manœuvres the active defence, the guns and field army. It is the object of the active defence to prevent the carrying on of siege works against the forts. As long as this can be done, the fort has nothing to fear but assault across the open. If the guns are silenced, whether in the forts or out of them, and the siege works constructed, the fort then has to protect itself against close assault. In either case, the fort only has to consider the ground immediately in front of it, unless it is hampered by the presence of guns. Against the close attack it is a question of glacis defence with quick-firing guns and wall-pieces, in which the fort most likely will have all the worst of it, even if it is possible to man the parapet under the enemy's shrapnel fire, which is more than doubtful. If the defence means to win, it must not allow the attack to reach this stage.

For the assault across the open, if the defender has enough warning to be able to man his parapet before the assailant reaches the obstacle, it should be enough. It is as well, however, for every reason that the fort should have more time and opportunity to develope its fire. Assuming the guns to be all outside, the fire of the forts will be machine guns and rifles. If a clear field of fire can be secured for these, of about 300 yards, they should suffice to prevent any troops from reaching the counterscarp. It is useless to endeavour to secure a broader field of fire, as while the attacking infantry were at a greater range than 300 yards, the parapet would probably be made untenable by shrapnel fire.

The fort, then, in order to develope its own resources to the utmost, wants to see clearly the ground in front for about 300 yards. It requires no more for any other purpose, as the distant defence is the task of the guns.

So far for frontal defence. As to flanking, it is a different matter. To fulfil the principle of the independence of the different parts of the defence, the forts must not only be responsible for themselves, but also for the intervals. To do this they must command the intervals, and be provided with flanking guns. The objections raised against guns in forts do not hold against those used for flanking, or only in much less degree, as has been shown in the last section. Also, the fort is naturally the best position for flanking the intervals. Again, if the fort-belt, as a unit of the defence, is entirely self-dependent, that is a kind of security against being taken unawares by the enemy. For if time pressed very much, all efforts could be turned at first to seeing that the forts with their flanking armament were complete ; then, the barrier being secure, the arrangements for the artillery positions could be proceeded with.

Though it is not necessary that a fort should be concealed from the enemy's view, as a well-designed work should be proof against his fire, yet, from the point of view of the assault, it may be desirable. Imagine an attacking party advancing against a work which they cannot see. After climbing a slope, and undergoing heavy losses from the howitzer fire of the defence and the flank fire of the supporting forts, they suddenly gain a plateau, and see before them at short range, the fort. The whole plateau is swept by rifle and machine gun fire ; in two minutes they have lost half their force and are over the brow again. After a few such experiences the plateau would begin to stink in the nostrils of the besieger.

Finally, still assuming the guns to be in positions outside the forts and connected with the circular railway, that railway should be in rear of the forts, and, for the most part, so should the gun positions. If not, their safety would to a certain extent depend on the outposts maintaining themselves in front. This might not always be possible, and would sometimes entail great and unnecessary hardships in severe weather. Besides, the advanced positions would not be tenable if the attack began to succeed, and it is unadvisable, on economical grounds, to have more than one set of positions for the artillery. Neither is there any need of it, as three or four hundred yards, more or less, is not a matter of much importance to long range guns.

In holding this view, I believe I am at variance with the latest French idea, which is to throw forward the batteries, letting the forts act as support for them.

The following are the site requirements for the forts in accordance with the above views :—That their parapet fire should sweep the ground in front of them for about 300 yards. That their flanks should command the whole of the interval up to the neighbouring forts. That there should be in rear, and close up, unseen ground for the guns. That the outpost positions should be close enough to the fort and gun positions to be thoroughly defended by them. That the neutral ground in front of the outposts should be entirely under their view for as great a distance as possible.

The ideal position would then be a ridge or plateau about a quarter of a mile broad, not commanded from the enemy's position, not much raised above the ground in front or rear, and having a wide stretch of open ground in front of it. The outpost positions would occupy the front brow, the forts the rear brow, and the guns the low ground behind the ridge.

The distance between forts I make 3,000 yards, in order that the front of each may be swept from both sides, at the maximum range at which it will be possible to get good observation of the effect of artillery fire on the attacking infantry. The flanking guns must be mounted so as to see the intervals, as indirect laying is not suitable against infantry in action. The 12-pounder field gun should be a sufficiently powerful weapon for the purpose of flanking the intervals.

It should be noted that the interval sometimes recommended is 4,000 or 5,000 yards, a maximum arranged so that the flanking fire may cross over a portion of the line, and to reduce the first cost of the fort line. I think it is more practical to allow at the start for the effective defence of the front of a fort by the collaterals, and though, no doubt, field guns may produce results against infantry at 5,000 yards and over, their action is crippled for want of observation. Also, the longer intervals leave a gap if a fort is lost by accident.

We have now to consider the type of the individual fort. On *Plate* I. some plans and sections of the types lately constructed are shown. They are taken from the *Fortification permanente et semi permanente*, published at Brussels in 1884, a very excellent and clearly arranged treatise, dealing, however, only with accepted ideas.

The traces are lunette, as usual, faces varying from 55 to 125 metres, and flanks from 45 to 100 metres. Front and flank ditches defended by caponiers ; gorge bastioned.

The only important differences between the French and German forts shown are in the organisation for defence and the disposition of casemates. In the German forts (*Fig.* 1, *Plate* I.) there is only one line of defence (not counting the detached wall), artillery and infantry sharing the one parapet. The casemates are placed under the gorge, on ditch level. In the French system (*Figs.* 2 and 3, *Plate* I.) the central cavalier is the main feature ; it serves three purposes, viz., as a parapet for infantry fire, commanding the glacis and the front parapet where the guns are mounted ; as a parados for the gorge ; and as a protection for the casemates, two tiers of which are placed under it looking to the rear.

The German works have no parados, but there is a traverse on the capital covering the communication from front to rear.

Both classes of works are on what may be called the compromise system. They are intended, of course, for guns, and the requirements of the guns have decided everything as to their site, command of parapets, etc. But to all appearance the guns are left unprotected upon their parapets, no sort of overhead cover, or even facilities for extemporising blindages, being indicated.

The French book already mentioned contains a very fully worked out Austrian project for a detached fort. It is small but powerful. A blunted lunette, centre face 25 metres, outer faces 40 metres, flanks only 30 metres on crest; armament, two cupolas in front of centre face, nine guns on faces and flanks, heavily traversed, and an inner parapet, apparently intended for the unseen fire of a few howitzers. Ditch defence, counterscarp galleries at the shoulders, and two small caponiers on either side of an entrance court flanking the gorge. The detached wall, apparently the only place for infantry, as there is no room for them between the guns. Casemates, mostly under the gorge. The fort is very neat and compact, but a terrible shell trap.

One of General Brialmont's type forts may very well be compared with these. It is that shown in *Plate* XIII. of the atlas to the *Fortification du Temps Present.* It appears from the text to be calculated for 500 gunners and 225 infantry, with 450 additional infantry to be thrown in when attack is expected. Form—blunted lunette, faces 80 and 90 metres on crest, flanks 115; guns, on parapet of faces and flanks, 20; 3 in cupolas, one at each shoulder at exterior slope, and one in keep. Ditch defence, masked caponiers, also musketry galleries in escarps; ditto in counterscarps in front of caponiers. Cupolas apart, the special features of this design are the infantry position and the introduction of the keep. General Brialmont agrees with the French in the use of two lines, but not in the manner of their use. The French have the two lines available, the parapet and the cavalier, and the only question is, which shall carry the guns; the cavalier having the high command of 40 feet and the parapet the low one of 20 feet. General Brialmont's parapet, about 30 feet above ground level, is taken up by the guns, and a second line is found for the infantry by running a trench along the exterior slope just high enough to allow them to see the glacis.

The keep is a one-storied masonry structure covered with earth, occupying the rear centre of the work, and projecting to the rear across the gorge, whose parapet and ditch it flanks. It is completely cut off from the work by an all round ditch, defended by escarp and counterscarp galleries. On the top of it and surrounding the cupola, is an infantry terreplein and parapet in earth. The whole is concealed from the enemy by the front parapet, though not in any way protected.

Radiating from the keep and near enough to the gorge to serve as parados, are two portions of parapet forming retrenchments and organised for infantry. Behind them, mortar positions can be arranged.

The casemates are placed under the front face, under the retrenchments (2 tiers), and in the keep.

Of the different types here described, the German obviously bears the palm for simplicity, while the Belgian, at first sight, appears strongest, as also the most expensive.

As the Belgian work has several distinctive features, I propose to consider them first, and then take the several defensive elements that are more or less common to all the forts described. Concerning the emplacement of the guns nothing more will be said, as that has been discussed in the last section. It may be observed, however, in passing, that the whole discussion as to high or low parapet mounting is completely out of date.

The Keep.—This is an element in favour of which General Brialmont is very strong, though he does not carry Continental practice with him. The main arguments he adduces for them are that they give more confidence to the men, and that they assist in the retaking of the fort; also that they permit of reducing the guard garrison. It is worth while to examine these arguments, as, if sound, they should carry much weight, while, at the same time, a keep, being an expensive structure, should not be lightly adopted.

A considerable array of opinion is quoted in favour of the keep. Napoleon would have them.* Vauban also states that "to determine men to defend a breach vigorously, they must have close behind them a solid keep or retrenchment, wherein they may feel they have a support near at hand." Cormontaigne makes the singular declaration that he thinks one is not *justified* in defending a breach unless it is retrenched.

* One of the few amusing sides to controversial literature is the buffeting the old authorities undergo. When they agree with you on some point, they are dragged out and pointed at, they are "the excellent," "the irrefragable;" but when they disagree, and the world knows it, on some other point, they are passed by with the casual remark that they did not know everything. So with poor Napoleon, who, on this occasion, however, gets great kudos for his opinion.

Napoleon's best reason for using a keep was that it gave greater security with a small guard, but that was, of course, in other times when a keep would be so designed that guns mounted there could sweep the parapet with grape.

The other authorities meet us fairly, on the ground of moral support. It is a question of opinion and human nature; no doubt they are right as to some descriptions of troops, but, as a general rule, I adhere to the opinion already stated that the single line is morally the strongest.

It would be difficult to prove that the most brilliant and determined defences recorded were not on single lines. Take Clive's defence of Arcot. With a force of 500 men, reduced eventually by losses to 80 Europeans and 120 Sepoys, he defended an enclosure of 2,500 yards against an army of 8,000 natives and 250 French. The ditch was dry and choked up in many places, the wall is described as "man-high." After a time there were two broad open breaches. About the fiftieth day of the siege a severe assault was made on both of them, which he beat off cheerfully. The siege was raised. Yet here was no talk of keeps.

Such instances might be multiplied, but to no profit, for a war of sieges is more than any other a war of individuals. *Tant vaut l'homme, tant vaut la place*, which, being translated, signifies that a good commandant means a successful defence, while a commandant with a stomach-ache means an unconditional surrender.

Unfortunately the prolonged study of fortification appears to produce a tendency to cosset the men. Professors recommend an active defence, but they multiply their protective lines as if they were afraid ever to let their men come in contact with the enemy.

As to the assistance a keep may give when a fort is to be re-taken, of course it may be so designed. We shall see directly how far Gen. Brialmont has succeeded; but then the keep must be able to maintain itself. At the storming of Kars in 1877, when the outer parapet of Fort Kanly was taken, the Turks took refuge in the keep; but they only maintained themselves three or four hours, and then yielded to a threat of dynamite. Under modern conditions, and in the cramped space available in the interior of a fort, it is a very difficult thing to design a keep that shall not suffer much from the distant attack, shall be proof against the close assault, and also shall be capable of offence against the enemy in the fort.

If anyone could do this, one would say it should be the Belgian engineer, with his belief in keeps and his long experience of design.

In the instance under consideration, the keep is by way of defending itself with its escarp gallery, and sweeping the terreplein of the work and flanking the gorge parapet from the earthen parapet on top. How much chance the roof section of the garrison of the keep have of fulfilling their task, may be seen from the fact that the enemy lining the parapet of faces and flanks can bring a converging and very much superior fire on them at 100 yards range, and with a command of from 10 to 15 feet above them; the traverses of the front parapet have even a command of 21 feet above the crest of the keep parapet. The rear portion of this parapet, which is passed through the gorge to flank its parapet, is overlooked and clean enfiladed from the front parapet. It is obvious, then, that troops could not maintain themselves on the top, but would at once be driven below. Their situation would then be more romantic than useful, and how long they could maintain themselves in the casemates under the action of burning straw in the ditch (easily obtained from mattresses in the other casemates) or such other simple means of offence, would be a pleasing experiment for the enemy. The parados would give no assistance, in fact they are worse than useless. They could not be held for five minutes, as they are connected with the flank parapets and enfiladed from them, while their inner ends are 15 feet above the keep and less than 50 yards from it.

On the whole, then, the example of such a work as this does not add much to the arguments in favour of keeps.

The Fausse-braye.—This arrangement does not belong exclusively to Gen. Brialmont, as the French and Germans appear to have made some use of it, especially in connection with pan-coupés at the angles. We here find it, however, as a continuous position for infantry, running along the faces and part of the flanks, and, in addition, flanked by a disappearing mitrailleuse cupola. It is a low parapet, some 13 feet thick, and giving about 8 feet of cover to a path 5 feet wide.

I find two objections to this disposition. The first is that the position is a very compromising one for infantry. If, when the enemy is escalading from the ditches, the defenders of the ramparts by a common impulse of zeal mount the parapet to meet him with the bayonet, that is one thing; but it is quite another to place them, in cold blood, before the assault has come within reach, in a narrow trench, with the rampart at their backs and a contracted and difficult retreat at the flank. I believe that the very best troops would be liable to a feeling of discomfort in such a position, and naturally so, for should the attack overpower them in this trap not a man would escape. It is not in defence that you can afford to try men's courage so highly, unless, indeed, under such circumstances as an Indian mutiny.

Another objection appears to me even stronger. It is that after a heavy bombardment the infantry position would be entirely destroyed. What with the cutting down of parts of the parapet by shells, and the earth thrown back into the trench from craters in the rampart above it, the defensive profile would be simply effaced, and could only be restored by sapping. If the bombardment were continued this operation would be impossible, and the fort would be left without a line of infantry defence.

This objection applies with almost equal force to the upper terreplein of the keep, but this is of the less importance, as we have seen already that that terreplein is untenable.

The result of this examination appears to show that this fort, which at the first glance appears so strong, has the least defensive power of any. I think it is not only possible, but highly probable, that it could be carried by assault within three days of opening fire by a proper siege train. The fort and its neighbours would be overwhelmed by high angle fire, the guns dismounted and the gunners killed, and the fausse-braye demolished. The bombardment would then be kept up to such an extent that the garrison would think of nothing but getting cover, and an assaulting party would most likely succeed, in the dark, in getting within striking distance without heavy loss. The defenders making a hurried attempt to man the covered way, might be driven out with the bayonet; and then, since the upper parapet is organised with reverse slopes for indirect fire, there would be absolutely nothing to interfere with the crossing of the ditch by light bridges brought up with the assault. Of course, all this sounds optimistic, but such things have happened, and the astonishment of the defenders at such light treatment of a position they believed impregnable would aid the attack materially.

In returning to the examples of French and German works or ideas, and the elements that are more or less common to all modern detached forts under ordinary conditions, we are on ground that has been so often traversed that it will be difficult to avoid being tedious, and an apology is almost necessary for touching on some points.

The Trace.—There appears to be a tendency of late years to diminish the size of works. If guns are to be placed in them the development of crest line will, of course, depend on the number of guns; but if no guns, or only a small number, the fort should be, for economical reasons, the smallest that can defend itself. We shall then, probably, find that before we reach the limit of frontal extent below which the fort would lack defensive energy, another limit would be arrived at in the necessary capacity for storage and lodgment. I hope to go into the question under the head of Garrisons in a continuation of this paper, and for the present will adopt 100 yards as the minimum length of front for a detached fort.

In the shape of the fort, the only point in modern practice that appears to call for remark is the supposed necessity for keeping down the depth, as a protection against bombardment. The same principle is laid down as regards field works, but it appears to me that the day has gone by when such a disposition can be of any use. Against high angle fire, defilade of the terreplein is not to be thought of; whether deep or shallow on capital it is almost equally exposed. Since, then, reliance must be placed on covered buildings and communications, other questions will arise which will be of more importance than a few feet more or less of casemated passages. Convenience of access from one part of the fort to another must be obtained by the proper distribution of casemates; and all operations on the terreplein must of necessity be abandoned whenever the enemy opens fire. Further, it may be laid down that repairs of any extent on the surface will be impossible, and, therefore, that works should be so constructed as to require the least possible repair after bombardment. Any one who has read the account of the losses of the Russian working parties at Sebastopol, in repairing parapets and gun platforms, will have realised this.

The Gorge.—We find in all types the gorge proof against escalade, and in most cases prepared for artillery defence. This is consistent with the idea of a gap in the line and the systematic attack of the neighbouring forts from the rear. But how long the enthusiasts of the step by step defence could hope to fight their gorge guns under the fire from front and rear they would then receive, is a matter more of psychological than practical interest.

If there is no enceinte, and the gap in the line large enough for a siege corps to push through is at the end of the siege, then the gorge could only be necessary against an enveloping assault. Time does not allow of going into instances and arguments as to the chances of this kind of assault, I will, therefore, invite criticism by saying that where the garrison is weak, or the civil population capable of treachery, I would employ a gorge defensible against infantry; under other circumstances I would dispense with the gorge entirely.

The Parados.—As a position for casemates, this work may be most useful. As a cover, it is useless against high angle fire; and to assist the defenders of the gorge when attack is expected, it is not required, as the defenders need not man the gorge until the attack has come so close that the distant artillery fire would have ceased. From the close fire of the infantry in front, the gorge is protected by the front parapet, unless it is much higher than the latter, which would be a faulty construction.

The Obstacle and its Defence.—Perhaps no part of the modern fort has received so much criticism, with so little profit, as the ditch. What we expect to find in any project is a ditch some 30 or 33 feet wide, and 20 feet deep, masonry both sides; flanked sometimes by counterscarp galleries at the angles, but generally by caponiers, perhaps assisted by escarp galleries or a loopholed detached wall. The trail of the serpent compromise is more evident in these details than anywhere else in the fort. Everyone knows that compromise is the essence of the actual design under given circumstances; but to pure theory it is fatal. Here, for instance, in order to protect the escarp and the caponier, the ditch has been narrowed until bridging is everywhere spoken of as the natural method of attack; and yet the demi-revetted escarp shown in section is only screened from frontal fire at $\frac{1}{3}$ to $\frac{1}{2}$ its height. A very little breaching would destroy the value of this escarp as an obstacle, while a 20-foot counterscarp with flat ditch below is not too formidable. The detached wall also, if high enough to be a real obstacle, may be breached. As to its defence, it may be enfiladed from the glacis; or if arcaded, the defenders may be dislodged by hand-grenades thrown across the ditch. Again, the narrowing of the ditch has reduced the power of the caponier dangerously; not because of the smaller armament, for that is compensated by quick-firing guns; but because it may be blinded in a variety of ways. The caponier guns being kept low, for safety and for grazing effect, a systematic attack on portions of the glacis crest, close to the caponier, by heavy shells, might result in dislodging enough earth to mask its fire. Or a quantity of trusses of hay thrown down might produce the same result. Or, again, a number of smoke-balls dropped just in front on the windward side would prevent any aimed fire. These simple devices have often been the most effective in siege warfare, like the beehives dropped into the breach that some of us read of as cadets.

These possibilities are the more important when it is remembered that the ditch and exterior slope, being unseen from the rampart, depend entirely on the flanking fire for their defence; and, further, that the enemy being able to establish himself in the ditch, with reinforcements available, means almost infallibly the capture of the work.

No doubt, by spending enough money, the ditch may be made both broad enough and deep enough to defy assault. The question then arises, considering the defensive power that is now possessed by infantry behind an earthen parapet, is it worth while to go to enormous expense to add an obstacle that withdraws the assailant from frontal fire while subjecting him to a flanking fire that cannot always, or to the last moment, be reckoned on?

Proposed Type of Detached Forts.—In bringing forward for discussion two types of fort, I will commence by answering No, to the above question. Provide such an obstacle as will detain the assailant for a short time under your rifle fire, see that that fire has a clear field, and you have done enough. Putting expense aside, the too much is a worse fault in fortification than the too little; tending, as has been already noticed, to produce laxity and over-confidence. Then, if frontal fire alone is relied on, what must be the relief of the commander of the fort in disposing his defence. Instead of a dozen small detached parties, ten men here, and fifteen there, in underground chambers and galleries, with, perhaps, everything depending on the skill and determination of a corporal and his party—the scene of the most important struggle, the ditch, which is beyond his observation; instead of all this, a single continuous line of defence, all the men holding it in a position to be cheered by his voice and example, the whole of the attack and defence directly under his eye, and all parts of the parapet equally accessible to the reserve which he has posted under cover. Everyone knows what the value of the commander of a place is; the one method of defence makes him useless during the fight, the other gives him amplest scope and opportunity.

The principle of the continuous slope for frontal fire, as exemplified in the Twydall redoubts, is by no means a new one, but it has never, to my knowledge, been applied in a permanent work. The great drawback to it is that where the line of fire from crest over glacis requires a considerable slope, it is impossible to apply it. This would occur wherever the ground to be swept by the flank guns had much fall. In one of my works I have assumed such a slope for the flank fire that it has been necessary to fall back on a steep escarp flanked by caponier, but the caponier is small and cheap, and is well backed up by fire from the parapet. In the other case, assuming a flat site, I have been able to dispense entirely with outside flank defence.

The other points I have tried to keep in view were—to reduce the obstacle to a minimum; to expose nothing to the enemy's fire but earth; to have a safe and convenient position, close to their work, for the guard of the parapet; to make the bomb-proof cover quite safe, but in as small a quantity as possible; to have no small details of slopes, etc., that would only be made to be wiped out by a bombardment; and to employ a simple trace adaptable to any site.

To commence with the fort shown on *Plates* I. and II.: taking first the parapet, its height depends on the level of the gallery below. In dry soil the relief may be taken as that which will equalise *r.* and *d.*, the depth of ditch being assumed as given. Exposure of parapet is of no importance, as it is little liable to injury; but an increase in relief adds much to the distance from counterscarp, which is to be avoided. For the same reason the slope is kept as steep as possible, $\frac{1}{4}$ being taken as the maximum.

The banquette is six feet wide, intended to give a firm footing to two ranks of infantry, with room for the supernumerary rank; also for machine guns. There is a platform in rear eleven feet wide and seven feet below the crest, intended for the support.

The obstacle consists mainly of a counterscarp. It is only 12 feet vertical, but the bottom is paved with concrete, and so arranged in a series of slopes that it would be impossible to get a ladder to stand on it. The $\frac{1}{1}$ slope would prevent men from jumping or dropping down with safety; and the distance from the iron railing has been arranged so that it should be very difficult, if not impossible, to cross the interval by planks, or by throwing down bundles of straw till the gap is filled up. The employment of the railing in addition to the counterscarp is of doubtful advantage, and I should be inclined to leave it out, being satisfied with a good wire entanglement at the lower end of the slope.

The flanking batteries, and the reasons for their introduction, I have already mentioned

The gorge defence is bastioned, with the view that as on so short a line it is desirable that the flanking fire should cross or overlap as much as it may, I have made the curtain as long as possible. The dwelling casemates all look on the ditch, and are loop-holed to command it. In front of the centre portion an arcaded passage is left, to serve as a temporary shelter, which can be used for field guns, etc., without entering the fort.

The earth covering of the gorge is left quite plain to anticipate the action of artillery. It might with advantage be planted with a thick hedge. It is intended for infantry, to supplement the defence of the gorge, the defenders lying down at the top of the exterior slope. The same principle is followed in the flanks at the top of the casemates.

The casemate space is the minimum for the garrison required, taking for sleeping room two men per yard length of a casemate 18 feet wide. The number on guard are not allowed for. One casemate is appropriated for kitchen, one for guard, one for officers, one for non-commissioned officers, etc.

The guard on duty for the parapet is accommodated in the broad galleries running from the flanks towards the centre. Guard beds might be provided in these galleries.

Magazines for powder, ammunition, etc., engineer stores, general stores, would be most economically placed as shown, in small forts; or, if the position under the flanks without direct access to the air is considered too damp for the stores, they might be placed under the front parapet on the capital.

The communications run from either end of the gorge casemates, through the flank casemated batteries into the front galleries. Short passages lead from these galleries to the terreplein of the work, and thence ramps to the road in rear of the banquette. Another way on to the terreplein is provided by steps leading up directly from the passage in front of the gorge casemates.

The open flank batteries are reached by separate passages from the gorge, and also by an iron ladder and door from the neighbouring casemated battery. Both these open into the shelter for men and guns at the front end of the battery.

The top of the gorge parapet and the flanks can be reached from the terreplein of the work by steps roughly shaped in the earthen slopes.

The cover to the communications under the flanks serves as a parados for the open flank batteries.

A large traverse is erected on the terreplein of the work, which serves the following purposes:—It defilades to a certain extent the steps leading up from the gorge; it gives place for a few casemates on the terreplein, which would be very useful to shelter for a time the reserve in case of assault, or working parties, when fire was very hot; and it has in front a large mass of spare earth which can be made available for repairs. The casemates are light, of the rail and concrete pattern; they are not intended to give protection against the heavier shells, but against light shells and shrapnel.

The slopes are shown on plan with defined edges, for convenience of representation. In practice they would, of course, be rounded off, and every effort made for invisibility. If the fort were on a conspicuous site, the high mounds over the flanks would have an undesirable prominence of nine or ten feet, which would have to be met by a skilfully arranged background. The hedge on the top of the gorge would be useful in this sense.

The fort above described is intended for a high and dry site, and for all-round defence. The next type is designed for low ground, where water is found close to the surface; and for a fortress with strong garrison and loyal population, therefore, as before said, there will be no gorge.

The plan and sections will explain themselves. (See *Plates* IV. and V.). The casemates must now be placed under the front parapet, and this, combined with the fact that their floors must be above ground level, raises the crest considerably. A narrow passage to keep out the damp runs along the front of the casemates. At the rear of the casemates, where they look on the interior of the work, is an open gallery where the troops can parade.

The casemated battery is omitted in this instance. The open battery has the same command and protection as before, both cavalier and parados, though the latter is no longer needed as cover to communications. The site being flat, the flanks can have a continuous slope.

The cavalier will no longer be prominent, as it will be at about the same level as the parapet.

The flank battery will be entered through the shelter from the front casemates.

Communication with the front parapet will be by one or two iron staircases fixed outside the gallery, but mainly by a couple of ramps at the centre, leading up from the terreplein.

Behind these ramps, under the parapet, will be the magazine.

The faces of the casemates looking out under the gallery will have shot-proof doors and windows. They would thus act as a sort of keep, so that if the enemy carried the parapet by assault, he would be unable to establish himself in the interior of the work, and would have to remain on the parapet, exposed to the flank fire of the collateral works. If the casemates were lost, the enemy, as there is no gorge, would still be completely exposed to the fire of artillery and the counter-attack of infantry from the rear.

The weak point of the type is that if the assailant did succeed in making his way round to the rear, in spite of obstacles and the fire of the supporting troops in trenches, the infantry manning the parapet would then be completely exposed to his fire. Against this it may be argued that it ought to be impossible for him to get there if the supporting troops are properly disposed; and that if he did, he would be at least as uncomfortable as the defenders. I think it is quite worth while to take the risk, considering the economy of the gorge, and the great advantage of the fort being completely exposed to counter-attack.

There is one more point to touch on, and that is the use of parapet shields. The crucial time for the assault on works depending on frontal fire alone, would be when the assailant reached the crest of the glacis. If his skirmishers extended there could succeed in keeping down the fire of the parapet, the working party would have a favourable chance of dealing with the obstacle. The skirmishers lying down on the glacis would not present a very large mark; no larger, in fact, if the fire from the parapet was grazing, than would the infantry behind the crest. Much would, therefore, depend on steadiness and good shooting.

I am no upholder, as at present advised, of portable shields for use in the field; but in the case of a fort the conditions are quite different. There would, undoubtedly, be enormous advantage to the defence if they had loophole cover of some sort. Anything permanent, in the face of artillery fire, is out of the question; even sandbags require some little time to place, and there would hardly be time to get them in position between the cessation of the artillery fire and the arrival of the storming party on the glacis. But a light steel shield could be placed on the parapet by each man in an instant, with the result that the whole line would be practically invulnerable to musketry fire. The machine guns would also have their shields; and it then becomes almost impossible to conceive that a parapet could be won in the face of a fire so protected. Such shields, being of simple form, need not be expensive; the number required would not be more than about 150 for a small fort. They could either be brought up by the men at the moment of lining the parapet, or laid out beforehand along the interior slope. The space they would occupy in store would be trifling.

In concluding this paper, I can only renew the hope that some other officers, better informed than myself, will take up the subject and give us their opinions. If time had permitted, I had hoped to include sections on garrisons, general organisation of defence, and the field-works subsidiary to the forts. These, perhaps, may find a place in the *Corps Papers* later on.

I have to express my best thanks to Major G. S. Clarke, C.M.G., R.E., for his kind advice and suggestions.

Woolwich, 30th June, 1888. L. J.

PAPER VII.

THE LYDD EXPERIMENTS OF 1887.

By Major G. S. Clarke, C.M.G., R.E.

Peace experiments are subject to limitations—principally financial —which so greatly reduce the possibilities that it becomes more difficult each year to suggest trials likely to give useful results. We need data on a variety of subjects, and although definite deductions from peace practice can rarely be drawn, the wilder forms of speculation can be sobered down by hard facts. If, at Inchkeith, all the machine guns of H.M.S. *Sultan*, by firing 15,210 rounds under Wimbledon conditions, succeeded in hitting fifteen dummies who remained in fixed positions to be shot at; then clearly, given disturbing elements of every kind, a machine gun in a boat would not be likely to keep a heavy gun silent, as had previously been suggested. If H.M.S. *Hercules*, at Portland, by firing 6,939 rounds succeeded under similar conditions in dropping one bullet into the pit of a disappearing gun; then, as clearly, it is perfectly useless for ships to use their machine guns at all at such a target. Our ideas are necessarily steadied down by facts of this nature, even although ample room remains for wide differences of opinion in discounting the actual results obtained at practice.

The German siege train before the south front of Paris, during twenty-two days of bombardment, inflicted a total loss in Fort Montrouge of 29 killed and 137 wounded.* On the other hand, the French fired 181 rounds for every German touched, and at Strasbourg the total loss of the besieged from artillery fire was

* Admiral de la Roncière.

only 389. Evidently, therefore, a liberal discount must be allowed in drawing any inference from target practice. The guns of to-day are better in every sense than those of 1870; but the improvement tells both ways, and it is doubtful whether in actual results the present siege artillery will beat the Peninsula and Sebastopol record, unless the disparity of armament of the attack and defence is very pronounced. In one sense only can peace experiments be regarded as affording absolute *data*. They show the worst. What you cannot effect with a given number of rounds at Lydd, you certainly will not effect with the same number in siege warfare, and here, at least, we can all stand on common ground.

To avoid expense, it is generally necessary to conduct siege experiments in such a way as to obtain hits with the least number of rounds, and in making deductions from the results obtained, this important qualifying consideration should never be forgotten.

The following were the principal subjects of experiment in 1887:—

1. The degree of protection afforded to an emplacement by a crest formed of concrete supported against a wrought-iron skin plate.
2. The protection afforded by the horizontal shield with which it has been proposed in some cases to provide the HP. mountings of BL. guns.
3. The resistance of the overhead cover provided in the Twydall Redoubt casemates to high angle fire of siege howitzers.
4. The amount of protection against heavy splinters afforded by steel plates of various thicknesses, employed as extemporized cover in gun emplacements.
5. The probable effect of back splinters from shells burst in a bank at a short distance in rear of a gun emplacement.
6. The liability of filled shell to be exploded by the splinters of shell burst near them.

I. Attack of Protected Crest of Emplacement.

Target.—Emplacement (*Plate* I.) a semi-circular pit for 6-inch BL. gun on HP. mounting.

Crest specially formed of concrete supported by WI. ring tied into the revetment by web plates at intervals, attached to two outer angle iron rings, A B.

(*a*) *Range.*—2,100 yards.
Gun.—8-inch RML. 70-cwt. howitzer.
Projectiles.—Common shell. Direct action fuze.
Angle of Descent.—7° 44″

Thirty rounds were fired, of which four struck the exterior slope, eight the superior slope, one the concrete close to the crest, and one the horizontal shield; five rounds were blind. Deepest crater 5 feet. Greatest diameter of crater 16 feet. The single round which struck the concrete close to the iron skin ricochetted blind, merely bending in the skin $2\frac{1}{2}$ inches, and tearing the upper angle iron.

(*b*) *Range.*—2,000 yards.
Gun.—8-inch BL., Mark II.
Projectile.—Common shell. Small percussion fuze, experimental.
Angle of Descent.—4° 18′.

Ten rounds fired, of which one struck the exterior slope, three the earth superior slope, and one the concrete close to the crest at a point where it had been more than half breached by a howitzer shell of the preceding series. Largest crater 21′ × 20′ × 8′ deep. The single round which breached the iron skin carrying away a piece 2′ 9″ × 1′ 6″, the gap extending nearly down to the centre angle iron ring (C) (*Plate* I.)

Remarks.—The experiment may be regarded from two points of view; 1st, in reference to coast defences; 2nd, as affecting land works.

1st. In the emplacement of a coast battery, a protected crest possesses certain advantages. The parapet is brought well under the chase of the gun and degradation of the crest due to blast is averted; while, at the same time, any back action, whether by flash, earth, or sand, is prevented. On the other hand, with long guns, this action is rendered much less serious. Crest hits, obtained by the fire of ships, must necessarily be rare, and may be looked upon as pure accidents. At Alexandria altogether eleven such hits occured out of 1,620 rounds (7-inch and upwards), which were fired; but even of this number a very small proportion occured in front of gun emplacements, and the rest were wasted so far as any effect against the Egyptian armament was concerned. There appears to be no real probability of obtaining better results with new type guns, the projectiles of which at moderate ranges arrive with so slight an angle of descent even in the case of comparatively low batteries, that serious injury to the interior of the emplacement is hardly to be apprehended.

The danger to the crest becomes less as the height of the battery is increased, and in case of the new emplacements at Stone Cutters' Island, Hong Kong,* the 9·2″ Mark III. gun would give a horizontal trajectory at about 2,100 yards range, and a fall of only 6° at 4,800 yards. For all batteries at (say) 100 feet height and upwards the cost of a protected crest appears to be unnecessary, in the case of an emplacement for a long gun. In a coast battery, isolated crest hits from the larger guns have, at most, to be provided against, and this experiment did not serve to determine the effect of a single such hit from a high velocity gun. The solitary round from the 8-inch BL. which breached the protected crest, fell in the crater made by a previous round, the side of which presented a fairly steep face and held the projectile well. There is no reason whatever to suppose† that a single round from the 8-inch gun, or larger gun, on an intact crest, would have seriously injured it, unless the angle of descent were considerable, and this implies extreme range.‡ On the other hand, a crest of the form subjected to experiment would give *complete* protection against hits from QF. guns, at least up to the 36-pr. Under the accurate fire of these guns, a mere earth crest would undoubtedly suffer degradation, thus somewhat exposing the emplacement to view. A crest formed of concrete unsupported by a ring would, if hit very close to its inner angle, distribute dangerous splinters. The single howitzer round which struck the protected crest with a fall of 7° 44′ glanced without doing any harm whatever; but ships, if they ever elect to carry high angle guns, cannot expect to obtain crest hits, and this result, therefore, serves to point no moral whatever.

2nd. The case of land works is altogether different. Emplacements for HP. mountings, if employed in land defences, will be subject to both direct and high angle fire, which, provided that careful observations can be made, ought to be fairly accurate. Failing really good observations—a case that will generally arise if

* Height about 210 feet.

† *Pace* the Report, which states : "The experiment showed that iron protection of this nature is of no value if the parapet be struck by an accurately directed projectile fired with high velocity from a heavy gun." The experiment furnishes no direct evidence whatever in favour of this assertion, and the whole question practically turns upon the angle of descent.

‡ Thus in the case of a battery at its own level, the 8-inch BL. gun, with 87½lb. charge, would give a falling trajectory of 2° 21′ at 2,000 yards, and 9° 35′ at 4,000 yards; the 9·2″ gun giving similar angles of descent at 2,600 and 5,200 yards respectively.

the emplacements are judiciously sited and invisibility has been studied—the fire of the attack will be accurate in direction; but crest hits will only be obtained by the purest chance. If an emplacement for an HP. gun is treated on the martello tower principle, modern siege guns will be able to cut a way into it with certainty in a greater or less number of rounds, and a protected crest of this class will oppose no obstacle to the systematic formation of a breach. On the other hand, such a crest will give complete protection against single hits from siege ordnance* and its adoption materially reduces the area of horizontal target offered to the fire of rifled mortars. For some unknown reason, we have totally neglected the rifled mortar, of which large numbers have been made by other Powers. At the siege of Paris the SB. mortars, employed by the Germans in battery No. 23 on the the south front, were more feared by the garrison of Fort Issy than the rifled guns,† and the rifled mortars now available will unquestionably give far superior results. Krupp's 24 c.m. rifled mortar, weighing 1,700 ks., fires a 136-k. shell, which with a charge of 5·4 ks., and an elevation of thirty degrees, gives 3,314 m. range, the probable rectangle being 11 m. range by 50 cm. direction.‡ If good observations of the fall of the projectiles can be secured, this mortar would find useful employment against the emplacements of HP. guns, and although the horizontal target is small, § it will be worth while to reduce it to a minimum, while the wrought iron skin will not only give security against single crest hits from siege guns and howitzers, but will avert the effect of the splinters likely to be detached by lighter guns.

Summing up, therefore, it seems highly doubtful whether it is desirable to adopt this form of protected crest for coast batteries. In land works, however, cases may arise which will justify the expense. It should be noted that a *complete* ring supporting concrete was fairly well tested at Eastbourne in connection with the cupola trials, and that the Lydd experiment under consideration was designed to satisfy the

* This was fairly well established by the experiments at Eastbourne. On the other hand, a concrete crest unsupported by an iron ring will, if hit near the angle, detach a large and dangerous fragment into the emplacement, as was proved in the same experiments.

† Bellagerung von Paris. Heyde u Froese.

‡ Bulletin de la Reunion des Officiers.

§ At Bucharest 164 rounds were fired from the Krupp 21 cm. rifled mortar, at a target about 20 feet in diameter, without obtaining a hit, notwithstanding that the conditions were perfectly favourable, and that the fall of each shell was telephoned back to the battery.

doubts expressed as to the behaviour of a partial ring. Even with a less elaborate anchorage than that shown in *Plate* I., there is no reason whatever to believe that such a ring could be bodily displaced by a projectile. So thin a skin has not rigidity enough to transmit the shock, and is certain to be cut through, as actually occurred in the case of the single direct hit obtained at Lydd. Finally, it may be pointed out that the breaching of the ring would not have resulted in the jamming of the horizontal shield. The fragment was detached, and, at the worst, no more than a temporary jamming seems to be probable.

II. Attack on the Overhead Shield covering an HP. Gun.

Target.—Steel shield 16 feet 6 inches in diameter; thickness, 1 inch.

a. Attack by Common Shell.—This was combined with the preceding experiment, and the ordnance used, range, etc., are as given above

Of thirty rounds fired from the 8-inch howitzer, one struck the shield at about 1 foot from its rear edge. The shell merely made a slight indent, ricochetted, and burst on second graze.

The single round from the 8-inch BL. gun, which breached the crest, burst on graze, and one large splinter struck and dented the right rear upper surface of the shield, doing no real damage. The dummy gun was disabled.

Remarks.—The howitzer round struck the shield at the worst place—near the rear edge. This round may be taken, therefore, to prove the invulnerability of the shield itself to any shell from 8-inch howitzers with an angle of descent not greater than 7° 44′. At this low angle, however, no result could well have been expected. Whether this shield gives protection against 8-inch howitzer projectiles, striking it with considerably larger angles of descent; whether it would resist the far heavier projectiles of the 24 c.m. mortar; what would be the effect of a melinite shell, assuming a burst immediately on graze to be secured—these questions remain unsolved.

There can be little doubt that the shield is proof against any high velocity siege guns at any range at which there would be the smallest chance of obtaining a hit. It is to be noted that the dummy gun, dismounted by the round from the 8-inch BL. gun which struck the crest, was merely suspended from the shield at such a height as to be level with its upper surface. That this round would have disabled an actual gun, if in or near the firing position, seems unquestionable. There is, however, no reason whatever to suppose that the gun, if in the loading position, would have been put out of action.

b. Shrapnel and Machine Gun Attack.—Fourteen shrapnel rounds were fired from the 8-inch BL. gun at 2,000 yards, of which two burst on graze, and one after ricochet.

In all, fifteen balls and one splinter struck some portion of the shield; one ball hit the dummy gun; one ball passed through the opening; and one ball struck a dummy on ricochet.

One thousand rounds were fired from a one-barrel Gardner 0·45 inch machine gun, mounted on a field observatory 100 feet high; range, 1000 yards.

The recorded results were :—

Splashed on shield	27	bullets
Hit gun	5	,,
Iron skin of crest	4	,,
Pedestal of shields	1	,,
Mounting	1	,,
Dummies	1	,,*

It was estimated that from thirty to forty bullets entered the emplacement.

Remarks.—The Shrapnel practice was hopeless from the first. As pointed out by the recording officer, "The angle of descent of the lowest bullets of the cone of dispersion on the rear part of the shield was only $2\frac{1}{2}°$; on the front part of the shield $10\frac{1}{2}°$." The practice was discontinued as "bullets falling at this angle of descent were . . . . . . unlikely to pass through the aperture." It is scarcely probable that any enthusiast would attack by shrapnel fire a small invisible horizontal slot in a ball proof shield.

The field observatory was intended to represent the armed "tops" of a vessel, from which—it may have been supposed—a hail of bullets could be delivered into the opening, thus easily silencing a disappearing gun. The observatory had a command of 91 feet above the crest of the experimental gun. The "tops" of ships of war are at most 60 feet above the water level. Assuming 20 feet above high water mark to be the level of crest of the lowest coast battery emplacement, the Lydd observatory thus had more than double the possible command, and, to make matters worse, the

* Slightly injured by ricochet from mounting.

results were telephoned and the firing corrected accordingly. But for these somewhat exceptional conditions, the result would doubtless have been *nil*; even with these advantages, only one dummy was hit. This kind of experiment nevertheless has its uses. That worst obstacle of progress, an *idée fixe*, may in this way be modified, if not killed outright.

III. Attack on Twydall Casemates.

Target.—Reproduction of front of Twydall redoubt, 50 feet long (*Plate* II.), line of fire 65 degrees to crest line.

Gun.—8-inch RML. howitzer.

Projectile.—Cast steel common shell; burster 25lbs. 14ozs.

(*a*). *Range.*—1,600 yards.

Angle of descent.—26°. ($3\frac{1}{2}$-lb. charge).

Thirty-two rounds were fired, of which three struck the covering mass of the casemates, and of these two fell on the exterior slope where the effect was *nil*, and one on the top of the casemate, also without any apparent result.

(*b*). *Projectile.*—Cast iron common shell; burster $18\frac{1}{2}$-lb.

Range.—2,100 yards.

Angle of descent.—7° 44′ ($11\frac{1}{2}$-lb. charge).

Twenty-two rounds were fired, giving altogether 10 hits on the covering mass, of which seven were on the exterior slope, one on the superior slope, and two over front wall of casemate.

The general result was an irregular crater (see section, *Plate* II.) three feet three inches deep at the crest. The best single crater was 16′ 6″ × 16′ 3″ × 5′ 3″, but the shells filled in the craters caused by those which preceded, and no really cumulative effect as regards depth of breach was obtained. One round striking at a horizontal distance of 10 feet from the front wall of the casemate is stated to have cracked it, and to have bent down the roof of iron rails about half an inch.

Of 30 delay fuzes, 13 gave blinds. The rest burst their shells with a delay varying from three-quarters to three seconds. Of 24 direct action fuzes, two were blind and all the rest burst their shells on graze.

Remarks.—The experiment was thoroughly unsatisfactory from a scientific point of view. The shooting was indifferent, the shells being unsteady. The practice took place on five non-consecutive days, with an interval in one case of nearly a month. The direct action fuzes employed in the case of 24 out of the total number of

54 rounds fired, could only have produced any effect by defeating the purpose for which they were designed. Finally, the three shells which alone struck directly above the casemates and their front wall, all ricochetted, and burst subsequently, doing no damage whatever. The fact that these three shells were not held is worth remark.

What positive deductions can be made from an experiment so unfortunate ? Probably none. The best single crater above referred to may fairly be taken as an index to the maximum effect obtainable in soil of this nature by the steel shell employed, with an angle of descent of 26°.

It is certain that a single crater of this description would not have breached the casemates. It is equally certain that a second shell falling exactly on the undisturbed crater of the first *would* have done so. There is room here for any assigned divergences of opinion as to the security of the Twydall casemates. The report, with judicial moderation, remarks—" On the whole, the experiment appears to show that a large expenditure would be necessary before an effective breach could be made by powder-filled shells discharged from heavy siege train howitzers." The Twydall casemates are faulty in design, since each should form an independent cell by which the effect of a fortuitous coincidence of successive craters would be localized without adding anything to the time required for construction. If these trials are considered in connection with others of the same class, and if any reasonable correction is applied on account of the difference between siege conditions and Lydd target practice, the conclusion appears inevitable that, *in ordinary soil, works can be built in three weeks with casemate cover, which it would be hopeless—in war—to attempt to breach with such siege ordnance as the 8-inch howitzer.* The long shells of the 24 c.m. Krupp mortar, with a good delay fuze, may be expected to give somewhat better individual results ; but the mortar will fall short of the howitzer in accuracy.

IV.—The Protection against Heavy Splinters afforded by Steel Plates employed at Extemporized Cover.

Target.—Sunken battery with two emplacements, separated by a traverse, and provided with dummy guns. The front portion of each emplacement was roofed over by six steel plates (thickness, $\frac{15}{16}$-inch, $\frac{3}{4}$-inch, $\frac{1}{2}$-inch, $\frac{1}{4}$-inch), extending nine feet to the rear, openings being left for the guns ; plates anchored into the parapet, and sloped 5° to the rear.

Gun.—8-inch howitzer.

Projectiles.—Cast steel shrapnel, and cast steel common shell.

(*a.*) *Range.*—1,600 yards.

Angle of Descent.—18° 24′ ($4\frac{1}{2}$-lb. charge).

Twenty rounds of shrapnel were fired, giving about 34 bullet hits and two splinter hits on the target plates. Effect *nil.* Twenty rounds of common shell were fired, of which eight had middle sensitive time fuzes, yielding seven bursts in the air. All the rest burst on graze. No hits obtained on target plates.

(*b.*) *Range.*—2,400 yards.

Angle of descent.—9° 12′ ($11\frac{1}{2}$-lb. charge).

Six rounds of cast iron common shell, with direct action fuzes, were fired. After three wild rounds, a direct hit was obtained on the front edge of one of the $\frac{15}{16}$-inch plates, which was thrown 17 yards to the rear. All the dummies were hit, and the dummy gun shattered. The carriage was very slightly injured.

Remarks.—The object of the experiment was not attained, inasmuch as no "heavy splinters" struck the plates. Hits of this class were scarcely to be expected from the six rounds common shell used with direct action fuzes. Even the $\frac{1}{4}$-inch plates proved capable of resisting the balls of shrapnel from the eight-inch howitzer; but this was perfectly well-known before. It is inconceivable that any artilleryman in the present day would employ common shell with time fuzes against such a target. The futility of the proceeding was recognized by Admiral Porter twenty-five years ago,* long before shrapnel had reached its present development. To burst a common shell in the air in front of an earthwork is merely to throw it away.

In so far as this experiment can be said to have a moral, it may be taken to indicate that emplacements thus protected are proof against the effects of all shrapnel burst in the air. The balls of shrapnel from high velocity guns would have no chance of penetration on account of their small angle of impact. The only "heavy splinter" which shrapnel developes is the base with more or less of the body adhering. Whether shrapnel practice at an emplacement thus protected with a view to obtaining hits with the base—a body whose proceedings subsequent to the burst are peculiarly erratic—is a probable method of operation in war, may safely be left to the

* "All firing against earthworks when the shell bursts in the air is thrown away" . . . . "A shell now and then exploding over a gun *en barbette*, may have a good effect, but there is nothing like lodging a shell before it explodes."—*Orders to fleet before the bombardment of Fort Fisher.*

imagination. It was, of course, a foregone conclusion that a 180lb. shell lighting on even a $\frac{15}{16}$-inch plate must hopelessly overpower it. The particular shell which practically wrecked the emplacement at Lydd struck exactly at the crest, and would have been disastrous in any case, and it does not appear that the overhead plates aggravated matters. On the other hand, there can be little doubt that a shell striking the plates further to the rear would owe most of the damage it produced to the bursting screen thus deliberately provided. The question of the utility of this mode of cover reduces itself, therefore, to a balance of probabilities. Plates thus employed will provide great protection against all shell which a sensible enemy is likely to try to burst in the air, and also against all long range rifle and machine gun fire. Against the common shell, or long fuzed shrapnel of howitzers, this overhead cover will merely enhance the danger. On the whole, the advantages appear questionable. Against an enemy mainly employing high angle common shell fire, the plates are inadmissible. *Per contra* it is to be remembered that to plant a shell in an emplacement which has been constructed with an eye to invisibility, and *not* as a target, will—under siege conditions—require a large expenditure of ammunition, and that this overhead cover, assuming it to be compatible with a free handling of the gun, confers a sense of security which has a definite moral value under fire.

V. The Effect of Back Splinters from Shells burst in rear of Emplacement.

Gun.—8-inch howitzer.

Projectile.—Cast steel common shell; buster, 25 lb. 14 oz.; direct action percussion fuze.

Range.—1,600 yards.

Angle of Descent.—26°. 3½-lb. charge.

(*a.*) *Target.*—Row of 6-foot wood targets and dummies placed at foot of earth slope (1 in 7) of Twydall redoubt.

The nearest burst was 7 feet beyond the targets. No backward splinter effect was observed, but the earth was thrown back for 17 yards.

(*b.*) *Target.*—Row of 6-foot wood targets, placed 5 feet from foot of earth slope (1 in 3) covering Twydall casemates.

The nearest burst was 11 feet beyond the targets. No splinter effect, but earth thrown back. Another shell burst 14 feet from the targets, also without effect.

(*c.*) *Target.*—Row of 6-feet wooden targets, placed 15 feet from foot of shingle slope (1 in 4).

1. Burst on ground 4 feet beyond target. No splinter hit recorded.

2. Burst on ground 8 feet beyond target. Slight shingle effect recorded. No splinter hits.

3. Burst on shingle slope 26 feet beyond target. Shingle thrown back. Small stone lodged in target. No splinter hits.

4. Burst on shingle slope 28 feet beyond target. Shingle thrown back. Small stone lodged in target. No splinter hits.

5. Burst on shingle slope 34 feet beyond target. Shingle thrown back. One dummy pierced. No splinter hits recorded.

Projectile.—8-inch howitzer steel common shell, filled with gun-cotton, buried 3 feet deep, and fired by electricity.

(*a.*) *Target.*—Row of 6-feet wooden targets.

1. Burst in 1 in 3 earth slope 16 feet from target. No splinter effect on target. Crater 15′ × 13′ × 3′ 6″ deep.

2. Burst in 1 in 6 earth slope 12 feet from target. No splinter effect on target. Crater 16′ × 16′ × 1′ 6″ deep.

(*b.*) *Target.*—Row of 9-feet wood targets.

3. Burst in 1 in 4 shingle slope 19 feet from target. One shingle hit. Shingle mostly thrown against target in pulverised state. No splinter hits. Small splinters found at distance of 10 to 150 yards; two larger fragments at 20 to 30 yards. Crater 16′ 6″ × 13′ 6″ × 2′ deep.

4. Burst in 1 in 4 shingle slope 44 feet from target. One slight dent in target. No splinter hits; three picked up near. Crater 14′ × 14′ × 3′ 3″ deep.

5. Burst in 1 in 4 shingle slope 32 feet from target. No marks on target. Crater 14′ × 15′ × 3′ deep.

Remarks.—The experiment appears to show that the risk of injury to men or material from splinters thrown back is insignificant. Although bursts were obtained in an earth slope at 7 feet and 11 feet from the targets, and in a shingle slope at 26 feet, no splinter effects were recorded. On the other hand, a large amount of earth was thrown back, which, if not personally injurious, would unquestionably inconvenience the working of BL. guns. This effect was shown to be considerable even in the case of a burst at a distance of 24 feet from, and five feet above, the target. The steepest slope adopted was one in three, and the maximum effect probably takes place in a cone whose axis is at right angles to the slope, which would account for the want of result. The natural line of resistance may, however, be sensibly modified by the loosening of the earth caused by the entry of the shell. More effect would doubtless have been produced by steeper slopes. Again, the large angle of descent of the howitzer shell may, as the report suggests, have favoured deep craters and small lateral dispersion; but a shell from a high velocity gun, unless brought to rest before bursting, would be unlikely to produce any greater result, as the forward velocity would diminish the back action due to the burster. Moreover, a slope of 1 in 7, and even more, would certainly not hold such a shell, which would either burst on graze, or in the air after ricochet. In either case, the splinters would go forward. The shingle slope clearly showed its disadvantages, even though only one pebble appears to have acquired force enough to penetrate the target. The guncotton bursters gave no greater results than powder, though as the shells were buried at three feet depth, and fired at rest, the conditions were highly favourable to them. The effect of high explosives in breaking up a shell into very small fragments is well known, and this effect appeared to be extended to the shingle which was so far pulverised as to diminish its projective capability. It is worth noticing that the greatest depth of crater produced extended only six inches below the position of the shell. Will melinite give any better results?

VI. The Liability of Filled Shell to be Fired by the Splinters of Shells Burst near them.

Target.—Common shell, 9-inch, and 64 pr. with powder bursters, 8-inch with guncotton bursters, unfuzed and arranged in various ways with respect to the fired shell.

Fired Shell.—9-inch with powder bursters, 8-inch with guncotton, variously placed with respect to the target, and fired by electricity. Three methods of arrangements were adopted.

(*a.*) Target shells arranged in a circle standing on their bases, partly touching and partly separated at varying intervals, the fired shell being placed in the centre, either standing on its base or lying on its side.

(*b.*) Target shells arranged in a pile, with the fired shell interpolated in the centre.

(*c.*) Target shells in a row, touching and leaning against a revetment, the fired shell lying on its side with head touching target.

The principal results were as follows :—

a. (1).—*Target.*—Twenty-seven 9-inch shells.

Fired shell.—One 9-inch shell, lying down.

Radius.—Five feet.

Result.—Three shells hit and dented.

a. (2).—Repeated, but fired shell 8-inch with gun-cotton burster.

Result.—Twenty-two shells hit and scored; one cracked.

a. (3).—*Target.*—Twenty-three 64-pr. shells.

Radius.—Five feet.

Fired shell.—One 9-inch, lying down.

Result.—One shell exploded; three shells thrown to distances 12 feet to 21 feet.

a. (4).—Repeated, but fired shell one 8-inch with guncotton burster.

Result.—Six shells apparently exploded out of 11 shells broken up and dispersed; remaining 12 thrown to distances of 8 feet to 45 feet.

a. (5).—*Target.*—Fifteen 9-inch shells.

Radius—Two feet six inches.

Fired Shell.—One 8-inch with guncotton burster lying on side.

Result.—Eleven shells hit and deeply scored; two cracked.

a. (6).—Repeated, but target thirteen 64-pr. shells.

Result.—Ten shells broken up, most of them apparently exploded; three thrown to distances of 21 feet to 42 feet.

a. (7) *Target.*—Five 9-inch shells (*Fig.* 1).

Radius.—Eleven inches.

Fired Shell.—One 8-inch standing on base.

Result.—All shells dispersed, but apparently only broken up. One 9-inch shell at seven feet distance, and with head pointing towards the fired shell, exploded.

a. (8).—Repeated, but fired shell one 9-inch standing on base.

Result.—Two shells disappeared, apparently broke up; one shell thrown 18 feet and cracked through; two shells thrown 33 feet and 18 feet respectively and scored.

Fig. 1.

a. (9).—*Target.*—8-inch shells, with guncotton bursters; three 8-inch shells badly cracked laid outside circle (*Fig.* 2).

Radius.—Ten inches.

Fired shell.—One 8-inch with guncotton burster.

Result.—All shells destroyed but none burst ; guncotton thrown all round, one piece smouldering.

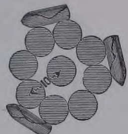

Fig. 2.

b. *Target.*—Seven 9-inch shells and three 64-pr. shell, in a row leaning against gabion revetment (*Fig.* 3).

Fired shell.—One 8-inch with guncotton burster, placed as shown (*Fig.* 3).

Result.—No shell exploded. One shell (previously cracked) had head broken off and burster exposed, but not fired.

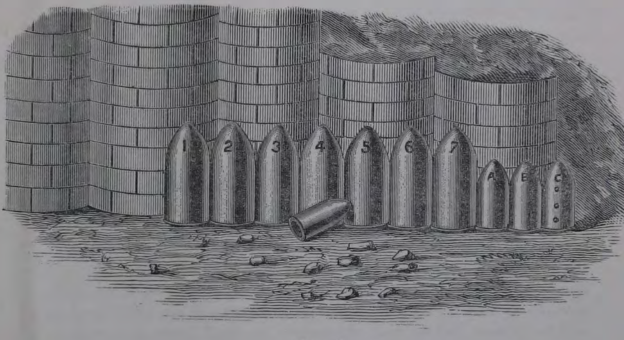

Fig. 3.

c. *Target.*—Fifteen 9-inch shells forming a pile (see *Fig.* 4).

Fired shell.—One 8-inch, introduced as shown (*Fig.* 4).

Result.—8 shells broke up and disappeared ; 5 shells left in crater much damaged ; 2 shells thrown 36 feet and 96 feet.

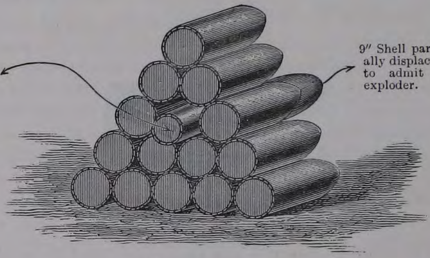

Fig. 4.

In addition to the above, 8-inch shells with guncotton bursters were arranged in circles of 7 feet 6 inches, 5 feet, 2 feet 6 inches and 10 inches radii, a similar shell being fired in the centre of each group. No target shell was exploded.

Remarks.

The experiment, so far as it went, was conclusive. As might be expected, the effect depended on the thickness of the walls of the target shell, and while only one 9-inch shell appears to have been burst, the 64-pr. shell suffered more severely, being exploded at distances of 2 feet 6 inches by a guncotton fired shell, and at 5 feet by both powder and guncotton. The single 9-inch shell was exploded at 7 feet from the burster, and appears to have been struck on the point. There was nothing to indicate that the employment of a guncotton burster, either in the fired shell or in the target, involved greater danger. There is no reason whatever to expect that fuzed shell would have given greater results, unless the fuze itself was fairly hit by a splinter. If the conditions of filled shell, stored—as they would be—close under a parapet, are considered, it will be evident that no risk whatever is incurred from shell exploding in the emplacement. A shell may even be broken up without firing the burster. The contention, that in coast batteries the proper place for the storage of shell previous to an action is the emplace-itself, appears to be amply justified.

Miscellaneous.

Various other experiments of less importance were carried out. With a view to ascertain "the extent to which guns mounted on the disappearing system are secure" against direct and curved fire, a dummy gun in a siege emplacement was pulled up and down, remaining one minute in the firing position, and three minutes under cover. At this target five rounds of common shell were fired from the 5-inch BL. gun at 1,200 yards, the last of which struck the mounting and would have presumably disabled a real gun.

Forty-five rounds were then fired at 2,400 yards, yielding one hit close to the crest which killed three dummies, and is stated to have disabled the carriage. The maximum error in line was 12 feet, and in range 150 yards short. Thirty rounds were then fired from the 8-inch howitzer at 1,200 yards without injuring the target gun, notwithstanding that one round fell and burst almost under the muzzle. The practice was corrected by observing parties thrown out to the right or left front. At 1,200 yards, the dummy could be easily made out at each appearance, and the 5-inch BL. gun was laid upon it. At 2,400 yards, it could only with difficulty be observed through a telescope.

Two rounds were fired at a clod of earth which was very naturally mistaken for the dummy.* This fact is very significant. The one minute period of visibility was of course five times as long as is necessary in the case of a permanently-mounted disappearing gun. A fair inference from this experiment seems to be that it would be practically hopeless to fire at a judiciously placed disappearing gun from the first artillery position ; but opposite deductions are, of course, open to other minds. In any case, it will probably be admitted that a target visible for periods of about 15 seconds, distinguishable only by the aid of a telescope, and capable of being confounded with a clod of earth, is likely to afford greater difficulties to the artillery of the attack than a cupola.

The shooting of the 0·6-inch wall piece is at last pronounced "satisfactory." This weapon, which appears to have now given results equalling those obtained by its predecessors in the mock siege of Juliers in 1861, has unfortunately been superseded during the period of its incubation.

* This experience was exactly paralleled in the Portland experiments, where the flag on the bomb-proof covering the range party developed a strong resemblance to the dummy gun.

Willesden paper was tried as a revetment, both in straight lengths supported by pickets, and as a lining for gabions of wire netting. The trials were not conclusive, but revetting materials of this class behave much alike under fire, and their principle advantages and disadvantages depend upon other considerations.* Willesden paper promises exceedingly well. On the other hand, the paper naturally failed to afford protection to a parapet against the blast even of a 4-inch BL. gun, and both it and the Willesden sandbags are liable to catch fire and smoulder, which unfits them for use in all positions where powder is stored or handled.†

A balloon was again tried as an observing station for directing artillery fire, and gave good results at a height of about 1,000 feet. It is stated that as regards the heights of bursts of time-fuzed shell, accurate observation was difficult. This is inevitable; but in actual siege operations, shrapnel alone will be used with time-fuzes, and no one but a balloon observer would have a chance of seeing the fall of the balls inside a work of defence. Failing balloons, it is not easy to understand how any really effective shrapnel fire can be carried out against the interior of a work. In such a case ordinary observations of the burst give little or no indication of the actual result.

G. S. C.

London, 7th July, 1888.

* The respective weights of revetments made of lengths of Willesden paper and of Jones' gabions are about as one to ten, and the Willesden gabion weighs only 6½ lb. against 34½ lb. for the Jones' gabion.

† Chloride of calcium would, doubtless, obviate this drawback; but the brine employed at Lydd appears to have been ineffective.

PLATE I.

ECTED CREST FOR A 6″ B. L. GUN,
YDRO-PNEUMATIC CARRIAGE.