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# CORPS OF ROYAL ENGINEERS.

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# PREFACE.

THE 3rd Volume of the New Series of *Professional Papers*, issued in four parts (No. 8, 9, 10 and 11) as *Occasional Papers* for the year 1879, has extended itself considerably beyond the average size of the annual volume, and hence some delay has occurred in sending it out.

Notwithstanding that the present volume contains over a hundred pages more than that of last year, it has not been possible to keep pace with the matter received for publication, and this explanation is due to those officers who have contributed papers which, although received some time back, have not yet been printed.

It will be found that while the new volume contains a fair amount of reading of especial value to the Corps, it also includes subjects of more general interest. Professor Huxley, F.R.S., very kindly delivered a lecture at the Royal Engineer Institute, Chatham, in 1878, on the "Geographical Distribution of Animals." It was issued as an *Occasional Paper* early last year, and is included in the present volume. It is hoped that it may be the means of calling the attention of officers stationed abroad to the great opportunities open to them of assisting in the advancement of scientific knowledge by simply using their powers of observation (having previously ascertained from competent authority what particular direction it is desirable that such observation should take), and by communicating the result to the Professor himself, or to some other scientist.

It has long been felt as a want that no complete history exists of our fortified places, and a good beginning has been made by Mr. Tregellas, in his "Historical Sketch of the Defences of Malta" to supply this deficiency. It is suggested that the subject should be taken in hand by those officers who not only have an inclination for antiquarian research—a study in this case all the more interesting to the military engineer from its connection with fortification—but have the opportunity of getting access to the many documents which bear upon the subject.

The lectures delivered by Major Helsham Jones, in December, 1878, on Afghanistan and our previous campaigns there, were issued last spring as an *Occasional Paper*, and will, it is believed, be found of special interest as a very concise and complete account of the campaigns of 1838-9 and 1842.

Notices of some of our *Papers* have appeared from time to time in the public press, and in some cases it seems to have been assumed that these papers were, so to speak, the mouthpiece of the Corps; it may not be amiss, therefore, to state that the responsibility for the theories enunciated and the opinions advanced in the *Professional Papers* rests solely on the writers of the articles, and that the Committee are glad to receive suitable contributions which come within the scope of this publication, although they may contain novel proposals and opinions antagonistic to those generally accepted.

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

*Secretary, R.E. Institute, and Editor.*

*February 6th*, 1880.

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# PAPER I.

## THE GEOGRAPHICAL

# DISTRIBUTION OF ANIMALS;

AND ON COLLECTING AND OBSERVING IN AID OF THE INVESTIGATION OF THE PROBLEMS CONNECTED THEREWITH.

BY PROFESSOR HUXLEY, F.R.S.

*A Lecture delivered at the R. E. Institute on 3rd April,* 1878.

WHAT we call physical science consists of the answers which can be given to questions concerning natural objects; and I think that, if you exercise your ingenuity to the uttermost, you will find that, in respect of any object in nature, all questions that can be asked can be reduced to one of four categories—either, first, what is the form and structure of the thing? or, secondly, what active powers does it possess? or, thirdly, where do you find it? while, finally, a thing having a certain form and structure, and certain active powers, and occurring in certain localities, the further question may be put, how has it come to have this structure and to have these active powers, and to occupy the place in which it is found?

In respect of living beings, the answers to the four questions which I have mentioned constitute what is known as Biological Science, with its two branches, Zoology and Botany. We call the inquiry into the structure and the form of a thing anatomy and development. We call the inquiry into its active powers physiology in its most extensive signification. We call the ascertainment of the position in which living things are naturally found the science of distribution. And, lastly, that great enquiry which sums up all the rest, and towards which all the others tend, is what is known as ætiology.

During the last two hundred years, some of these branches of biological science have grown so much, and the methods of investigation have become so complicated and require so much technical skill, that it is quite out of the question for anybody to attempt, either to know what is already known about them, or to increase the sum of knowledge, unless by many years of patient devotion to their study. No man, for example, can hope to do anything in anatomy, or in the great majority of the branches of physiology, unless he has given himself up completely, and for a lengthened period, to the acquirement of what is already known and to learning how to conduct his inquiries. But there are some branches even of what, in the broadest sense of the word, we may call physiology; and there is a great deal—in fact the greater part—of what is known as distributional science, in which it is still possible for anyone who is possessed of powers of accurate observation and of that most valuable of all scientific qualities, common sense in the interpretation of observations, to add something, and, indeed, to add a very great deal, to the store of knowledge. Anyone with fair observing powers and reasonable caution, and who has the opportunity, may obtain valuable information about the habits of animals. Of course we cannot all of us expect to be as successful interpreters of the phenomena which are exhibited by animals in their ways and works as a Huber or a Darwin; but still a great deal may be done by anybody who will give the time and patience to attend to them, and such information respecting a part of the mental phenomena of animals, comes under the head of physiology in its widest sense.

But there is still more to be done with regard to the science of distribution, which is, in the first place, the determination of the places in which the different kinds of living things are to be found in the state of nature. It is open for everybody who will use his eyes and be a little careful to ascertain facts of this kind for himself; and peculiar facilities for the extension of our knowledge on these subjects are offered to those who have the opportunity of sojourning for a considerable period in foreign countries; because, as concerns the great majority of living things with which we are acquainted, our knowledge is restricted to such chance information as is picked up by collectors, passing through a country in a short time and with a special object. There is almost no form of exotic life which might not be studied with profit, with infinitely more care than it has been studied at present, by persons who have the opportunities afforded by a residence in foreign countries. I propose to-day to say something about what may be done for the science of distribution by persons like those whom I have the honour of addressing; whose duty largely calls them into foreign countries and very diverse parts of the world, and who, therefore, possess exactly the kind of opportunities to which I have referred.

It should not be supposed that the duties and obligations of a soldier's life oppose any special obstacles to pursuits of this kind. Except during active service, that life is popularly supposed to have a good deal of leisure attached to it, and I may remind my hearers, of what they doubtless know by experience, that even active service is not incompatible with scientific pursuits; I mean with the pursuit of branches of science which lie outside the immediate profession of a soldier. One of the most distinguished naturalists of any age, Lamarck, the great French zoologist, somewhere about a hundred and twenty years ago, was a soldier on active service and a distinguished soldier, although he remained in the army but a short time; and it was while on active service that he laid the foundations of his subsequent remarkable career. And I may say, with regard to this particular subject of the distribution of animals, that it has a special appropriateness for the Royal Engineers, because it is a part of their duty—a necessity of their professional education—to be acquainted with physical geography and all that flows from it in the direction of military operations; and considerations of physical geography, as we shall see, enter in a most essential manner into the study of distribution.

Now I might adopt either of two methods in dealing with the subject of distribution. I might, on the one hand, put before you the broad general facts and, from the statement of those facts, indicate the sort of problems that are opened to us by distribution; or, on the other hand, I might take some special case and try to work it out in detail, in order to lead you, by another route, to the larger problems connected with the science. And, in scientific exposition, to my mind, the old adage of "*Dolus latet in generalibus*" is so strikingly applicable, that I always prefer a special case when I can get a good one. There happens to be a special case of a very familiar animal, with which I have been a good deal occupied lately, which, if followed out, will lead us to some of the most singular and most anomalous of the problems which arise in connection with distribution, and will enable us to see what large questions underlie apparently insignificant, and it may seem wearisome, details.

I daresay that you are all familiar with the common cray-fish which is found in certain of our rivers; and, in some countries, much more than in this, is considered a great delicacy for the table. It is very like a small lobster; in fact, it requires some care to distinguish it scientifically from the lobster. For those who are not quite familiar with the animal, I will point out these two figures, which give a view of the cray-fish from the back, and from one side (*Plate* I.). Like a lobster, it is covered over with a great shield in front, and has a moveable tail, as we call it, made up of six joints and a terminal one. There are large pinching claws in front; and behind these, four pair of legs with which the animal walks along the ground (*Plate* II.). Behind these, come five pair of small limbs under the tail, and then there is a single pair, which is very much larger, and which, together with a middle piece, makes the hind fin, by the stroke of which the creature propels itself through the water when it swims backwards. I do not propose to trouble you with any unnecessary details as to the structure of this creature, which, although an insignificant looking animal enough, might occupy us for a very long time; but there are one or two points which I must mention, otherwise you will hardly understand the difference between this cray-fish and others that I shall have to refer to.

In our cray-fish, you will find that underneath the shell, as we call it, on each side, there is a cavity, and in that cavity the gills are placed. You must all have seen the corresponding structures in a lobster, of these gills there are altogether eighteen on each side. Some of them have a very curious and characteristic structure, which you see represented in this diagram; but that I cannot stop to dwell upon. I will only ask you to recollect that there are eighteen gills, and more particularly, that there is one gill attached to the walls of the body (*Plate* III.), just above the hindermost leg (*Plate B* 14). Then, again, in the males, underneath the first two joints of the tail, the limbs are specially modified—converted into a very curious kind of apparatus, which I shall refer to as the styles (*Plate* II.), and I think that those points are about enough for my present purpose.

The cray-fish has received the scientific name of *Astacus fluviatilis*. You find it haunting rivers and running waters; creeping under the roots of trees, or digging pretty deep holes in the sides of the banks, into which it retires in the winter. Habitually it lives in the water, but it can take to the land, though rarely for long. The cray-fish is, to a certain extent, a vegetable feeder, yet it is also glad to obtain any kind of animal food which it can get. It does not even despise carrion. At the breeding season, just as in the case of the lobster, the eggs of the female are all collected together underneath the tail, and fastened on by little threads to the swimming feet, or false feet of the tail; so that, they correspond with the "berry," as it is called, of the lobster; and there these eggs are carried about in a sort of natural perambulator until they are hatched. The young cray-fish leaves the egg in much the same condition as the parent, only very small; and it is said, although I cannot tell you the fact of my own knowledge, that the cray-fish covers them as a hen does, and looks after her flock of young. But, at any rate, this much is certain—that, for some time after they are born, the young are firmly attached by their pincers to the false feet of the mother, and are carried about with her. These points in the structure and mode of life of cray-fish are of some importance for the present discussion, and therefore I have briefly dwelt upon them.

We have now to consider the geographical distribution of the cray-fish. We find it in the rivers of some parts of England and in Ireland, but not in Scotland. So that the species *Astacus fluviatilis* is distributed, to begin with, over a large area in Great Britain and Ireland. But, more than that, it occurs over almost the whole of the western part of the Continent of Europe—in Sweden, in Finland, in Western Russia, in Germany, in France, as far west and south as the Pyrenees, and in the basin of the Ebro about Barcelona. Whether it is found elsewhere in the Iberian peninsula is uncertain; but it stretches down throughout the whole length of Italy, into Sicily, and Northern Greece, and as far as the embouchures of the Danube and the Dniester, in the Black Sea. But there it comes to an end. You do not find this particular species *Astacus fluviatilis* east of the last mentioned region. Nevertheless, Eastern Europe and Central Asia are by no means devoid of cray-fishes. On the contrary, they are very abundant; but the cray-fishes which we find there are of a species distinct from *Astacus fluviatilis*. I will not trouble you with the details of the distinction, which would be wearisome. It can only be made obvious by a careful study and comparison of the two species. Still, they are distinguishable forms, and this second form is what is called the *Astacus leptodactylus* (*Plate* IV.). This species is met with all the way from the Arctic Ocean to the Black Sea and the Caspian, in the Volga, in the Bug and in the Don; and, moreover,—and this is a very curious fact—it habitually passes into the Black Sea itself and into the Caspian. As you are aware, both these landlocked seas contain salt water, so that this cray-fish, which, as a rule, is a purely fresh water animal, takes to the salt water, and takes to it very kindly. In fact it lives there so long, that some have been found going up the rivers again out of the sea, with barnacles of considerable age adhering to their backs, showing that they have lived for a long time in the sea water.

The facts may be stated in this way—that all the river basins which debouch either into the Atlantic or into the Mediterranean, as well as those which flow into the western part of the Black Sea, contain the *Astacus fluviatilis;* while those streams which belong mainly to the great Caspian area—to the basin of the Volga, and so on—those great rivers which stretch from the Black Sea and the Caspian northward through Russia and western central Asia, constituting a distinct geographical system of rivers, are inhabited by a distinct species of cray-fish, *Astacus leptodactylus.*

Now, let us go farther eastward in Asia. I have seen cray-fish from Manchooria, but I do not exactly know from what part, and Manchooria is a very large country. But we do not know much about the cray-fishes of central and eastern Asia, till we get to the river Amoor, which opens into the Pacific just north of the Corea. That very large river basin has cray-fish which are quite distinguishable from those already mentioned, and receive distinct specific names. One of them is called *Astacus dauricus.*

I have tried to represent these facts by colouring this map *(Pl.* VII.). I do not know the northern limit of these species, so all that is left vague; but there are said to be no cray-fishes in those Siberian rivers which run northward, such as the Obi and Jenesei. The southern limit, you will observe, coincides with a great feature of physical geography. It answers, as nearly as may be, to the northern escarpment of the great table-land of central Asia. At the present time, no cray-fish are known in Asia south of this table-land; so that upon the whole, the southern limit of the area of these different species of cray-fish is coincident with the greatest of all the features of the physical geography of Asia—namely, that vast table-land which stretches from east to west, speaking roughly, from China to the Black Sea.

Continuing our eastward course we come to Japan; and in Japan there is a species of cray-fish which is distinguishable from all those which I have hitherto referred to. It goes by the name of *Astacus japonicus.* This map, let me remind you, being drawn on Mercators projection, makes the northern distances far too great in proportion, so that it looks now as if we had to make a great jump. The next place, in fact, in which we find cray-fishes—confining ourselves to the northern hemisphere—is on the west coast of North America; that is to say, in British Columbia, in the Oregon territory, and in California. A skilful zoologist, Dr. Hagen, who has recently described these cray-fishes with a great deal of care, makes as many as half-a-dozen different species in this region.

Still further to the east, we come to the vast barrier formed by the table-land from which the Sierra Nevada and the Rocky Mountains arise; and coincident with this great natural barrier we reach the limit of the distribution of the genus *Astacus* itself. Probably, there is no country in the world more rich in cray-fishes than the central basin of northern America, which is occupied by the vast river systems of the Mississippi and the Missouri, and the Red River, and so forth, and which contains within its area the largest lakes of fresh water known in the world. Yet it is a singular fact that these cray-fishes, of which there are as many as thirty-one or thirty-two distinct varieties or species, one and all differ from the Eurasiatic cray-fishes in certain constant particulars. Hence they are formed into a distinct genus, termed *Cambarus* (*Plate* V.). One of the most important of these constant differences is the entire absence of the gill over the hindermost leg, so that there are only seventeen gills on each side.

Not only are the cray-fishes of the genus *Cambarus* spread over the whole of this great series of rivers, the most of which debouch into the Gulf of Mexico, but they are found as far south as Guatemala. They are also met with in Cuba; probably, in Jamaica;* and, I should think, very likely in Hayti, but I do not know whether they are found there or not. And, just as the cray-fishes which inhabit the outlying islands of the Old World—such as Japan and the British Islands—are *Astaci* with eighteen gills, so those in the outlying islands of the New World are said to be all *Cambari*—and have only seventeen gills on each side.

What has now been stated respecting the places in which these different forms of cray-fishes occur, embodies what is known positively of the geographical distribution of these two genera, *Astacus* and *Cambarus*.

In addition, there is the very curious negative fact, that, throughout the whole of southern Asia and the entire continent of Africa, up to this present time, there is nothing whatever known of any

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* Since the delivery of this lecture, I have received specimens of "Cray-fishes" from Jamaica. But they are really very large river Prawns; so that I am in doubt whether true cray-fish occur in Jamaica or not. I should be much obliged to Engineer officers stationed in Jamaica, if they will investigate this question.

cray-fish; neither *Astacus*, nor *Cambarus*, nor any of the other genera, to which I shall have to refer by-and-bye. The Nile we may look upon as thoroughly searched, and we may make sure that there are none there; and, at the other end of Africa, nothing is known of cray-fishes in Natal, or at the Cape of Good Hope. The Zambesi, that great system of lakes which has recently been discovered, and the Congo, probably, have not been thoroughly searched. Still it would be a very extraordinary fact if cray-fishes of any kind should now be discovered in those rivers, seeing that a good deal of attention has been paid to them. And this is just one of those points which I may venture to urge upon your attention, as exemplifying the opportunities which may be offered even to those who do not take the trouble to go scientifically into these matters, and by seizing which, anyone may largely aid that particular branch of science which we are considering. For example, I may suppose that, any of you stationed in India, or at the Cape of Good Hope*, and who in the course of sauntering by, or fishing in, a stream, might pick a cray-fish out of the river, would be as likely as not to throw it away again, thinking that such a thing as a cray-fish could not be of the smallest interest to anybody. But all I can say is that if any of you do find a cray-fish under these circumstances, I would beg you to be good enough to put it up in the safest manner you can, and send it to me by post at the earliest opportunity. I shall be particularly glad of it, and happy to pay all charges. If you could even sacrifice the contents of that flask which so many wanderers carry about, and put it in spirit, that would be better still, because then I might have some chance of examining into some of the deeper points of its organization. But, in these matters, negative facts are almost as good as positive ones, if you have your minds open to the importance of questions of this kind. Even the fact that a diligent sportsman or fisherman has never seen anything like a cray-fish, in rivers that he has happened to fish, is a fact of importance—not quite so good as finding one, but still very good in its way.

Now, let us look at the southern hemisphere, and inquire what we find there. There are cray-fishes in Australia and Tasmania, of several, probably many, different species. In Australia, certainly

* In fact, a Crustacean is said to exist (as I have remarked further on) in the upland streams at the Cape of Good Hope, of which no specimen exists, so far as I am aware, in our museums. It has been placed among the lobsters; and the ascertainment of its real nature would be very interesting. Will Engineer officers, stationed in the Cape colony, be so good as to obtain specimens.

three different genera occur; I mean forms as distinct as *Cambarus* and *Astacus*; and I am told, that very large cray-fishes, as big as the smaller lobsters, are brought to market in towns like Melbourne, and are a great article of diet there, so that the cray-fish is a rather important constituent of the fauna of Australia. It has long been known that these cray-fishes differed from our common cray-fishes in certain external characters. Having been struck with the singularity of the distributional problem offered by the cray-fishes, I happen to have been looking at this matter rather carefully lately; and I find not only that there are these superficial differences, but that there are considerably deeper structural distinctions. For example, the Australian cray-fish have twenty-one gills on each side; and, of these twenty-one gills, those which form the outermost set have not that singular expanded plate at the end which is so very characteristic of the gills of our cray-fish. There is at most a mere indication of it, but nothing more. Then there is another very curious thing. In examining the anatomical structure of our cray-fish some time ago, I found, in addition to the eighteen gills that are already known, two little filamentous processes not more than the sixth of an inch long. Each of those had the same structure as one of the filaments of the gill. I will not trouble you with the reasons for my conclusion, but I had no doubt that these were rudiments of gills—that they were like the dew claw of a dog, which, is a rudimentary toe. They were structures which had ceased to have any important function, but of which the remains were still discoverable.

Well, that set me thinking that if I had here eighteen functional gills and two rudimentary ones, there ought to be some kind of cray-fish which had functional gills in the place of those rudiments, occupying exactly the same position; being, in fact, the two breathing organs, of which these two filaments represent only the withered and, as it were, useless remains. I did not happen, at that time, to possess any Australian cray-fish, but I knew that a friend of mine had one of them in spirit: and that exemplifies the importance of putting these things in spirit. I asked him to be good enough to let me examine it carefully, and, to my very great satisfaction, I found the gills which I expected to find. I had reason to think, from many points of the structure of the Australian cray-fish, that it was what we call a less specialized form than the European one, and I felt pretty confident that I should find in the Australian cray-fish, in a functional state and fully developed, the gills of which the mere rudiments were to be met with in the common cray-fish; and when I looked carefully I not only found them, but I found one gill more. Thus these Australian cray-fish have altogether twenty-one gills. That constitutes one of their great distinctions; and another is that the males are entirely devoid of those styles which we found in the males of the common cray-fish.

Now, not only do you find peculiar cray-fish, which constitute the genera *Artacopsis* and *Chæraps* in Australia; but in Tasmania, which, is separated by a wide strait from Australia, there is an allied but different genus *Engæus*. These cray-fish have taken to land habits. they leave the water altogether to burrow holes in the ground, and live habitually in gardens, where they do a great deal of mischief. In New Zealand, which, as the crow flies, is more than a thousand miles from Australia, cray-fish of the same type, though of a different genus, occur.* Strangely, again, in the Fiji Islands there are cray-fish which are very similar to the New Zealand ones, although the Fijis are, like Australia, separated by more than a thousand miles of sea from New Zealand. That is not all. Cray-fish, presenting nearly the same differences from those of the Northern Hemisphere, are found in Chili, in Southern Brazil (*Plate* VI.), and in Madagascar. Now, it is exactly this fact—that you find kinds of fresh-water animals so closely resembling one another—so completely upon the same type, that that they must be regarded as closely allied forms—in Madagascar, in Australia, in New Zealand, and in South America, which is so singular. There are very few other cases of like kind among the higher animals. There are two groups of fresh-water fishes of which there are species in South America, in New Zealand, and in Australia; but, in these cases, there is no representative of the genus in Madagascar; so that the cray-fish case is perhaps the most remarkable one of its kind of which we have any knowledge. Consider these distant points of the earth's surface, separated by vast areas of sea, which, of course, no fresh-water animal can traverse; yet the rivers of each are inhabited by animals which are so thoroughly alike, not only in all the essentials of their structure, but in many details that it requires the practised eye of the naturalist to distinguish the one from the other.

These are the broad facts of the case at present ascertained,

* I believe that Engineer officers are stationed in the Fijis. Specimens of the Fijean cray-fish, preserved in spirits, would be particularly acceptable, as I have seen only a couple of badly preserved specimens. The Tasmanian *Engæus*, also is rare, and its habits are so peculiar, that it would be well worth especial study.

and you will observe that there is still a great deal to be learned. Although I have no reason to doubt that there are no cray-fishes in Africa, yet I should very much like to have the question more thoroughly investigated. Towards the end of the last century, a well-known naturalist, Herbst, described and figured an animal very like a cray-fish, which he called *Astacus capensis*, from the fresh waters of the mountainous parts of the Cape of Good Hope. But the same animal is ranged by later writers among the marine lobsters, and its history needs re-examination. It certainly will be surprising if there are no cray-fishes in the Euphrates or in the Tigris. I have every reason to believe that there are none; but until those waters are thoroughly searched it would be hazardous to speak positively. With regard to India, however, there can be no doubt. India has been thoroughly searched by very competent naturalists; and my friend, Mr. Wood Mason, who is at present curator of the museum at Calcutta, assures me that there is no trace of a cray-fish anywhere in Hindustan. How far the same negative may hold good for Indo-China and for China itself it would be, perhaps, a little hazardous to be confident; but I have no reason to think that any cray-fish exist there. And the like is true of Malaisia, including the great islands of Borneo and Sumatra. Cray-fish are sometimes said to be common in Mauritius. But by the kindness of Sir Henry Barkly, I have recently been enabled to satisfy myself that the the "Cammarons," or so-called cray-fish of that island, are fresh water prawns. Whether cray-fish exist in New Guinea, or not, I cannot say. New Guinea is just now beginning to be explored. Its fauna has a great many affinities with that of Australia, and it is quite possible that cray-fishes may be discovered there.

I have ventured to point out, more than once in the course of this lecture, that persons whose minds have once been led to consider the singularity of problems of distribution can often give us great help, even though they have had no scientific training. The naturalist, sitting in his study, cannot develope, out of his inner consciousness, in Teutonic fashion, the geographical distribution of cray-fish. He must trust entirely to the reports which he receives and the information which he gets from those who have had an opportunity of visiting various localities; and while a careless person, if he will only keep his eyes open, may in this way render some service, a careful observer may do great things in aid of the study of geographical distribution.

"But," you may ask, "what does all this come to; and what sort of human interest can attach to knowing whether there is a cray-fish here, or a cray-fish there?"

Well, to that I would reply that things do not happen by chance in this world—that whatever is, is where it is in virtue of a long chain of causation. Some philosopher once said—(it sounds like an exaggeration, but it is nevertheless true enough in its way)—that the history of the whole universe is somehow or other wrapped up in everything we see, if we only possessed the knowledge and the acuteness required to trace it out. Now, that is emphatically the case with regard to living objects. If there are cray-fishes in the Fiji Islands that sounds like a very small piece of information indeed. You might be inclined to reply, in the terms of the old verse about the fly in amber—

"The thing itself is neither rich nor rare
The only wonder's how the —— it got there."

But it is exactly this question of "how it got there" which opens up such an interesting field of inquiry. The nearest land to the Fijis, in which cray-fish of like kind occur is New Zealand. But although, as I have already mentioned, there is reason to believe that *Astacus leptodactylus* (and perhaps even *A. fluviatilis*) can adapt itself to life in sea water and even live permanently therein in a sea like the Caspian, there is no probability that cray-fishes can spread over a thousand miles of deep open ocean, already tenanted by numerous enemies and formidable competitors. All the means of transport by which the eggs of some kinds of fresh water and land animals are transferred over long distances are shut off from the cray-fish, because, as we have seen, the eggs are carried about by the parents until they are hatched; so that we can say, as positively as we can say of any matter of probability—that it is impossible that the cray-fish should have got from the one place to the other, under the present conditions of nature.

But we need not go so far as the Fijis. The like difficulty is presented by the cray-fish of our own island. They are specifically identical with the cray-fishes of Western Europe, and either they must have spread from Ireland and England to the Continent of Europe, or they must have spread from Europe to England and Ireland; and, inasmuch as that spreading appears to be impossible under the present geographical conditions, the question arises, by what means can they have reached the position which they at the present occupy?

I think we may put one supposition aside as not worthy of any serious consideration. I do not suppose that any one will now seriously suggest—I do not know that there would be warranty of any sort for such a supposition—that the *Astacus fluviatilis* was created separately in Ireland, in England, and in France; that the very closely similar *Astacus leptodactylus* was created in the basin of the Caspian; the *Astacus dauricus* in the basin of the Amoor, and the *Astacus Japonicus* in Japan. So we may dismiss that supposition altogether, and consider what natural agencies, of which we have cognizance, are competent to bring about such a very curious state of things, that we find, spread all over the northern hemisphere in very different localities, often so separated by intervals of sea from one another that any means of transport is not discernible, one great group of closely-allied cray-fishes; and that, far away in the southern hemisphere, separated by still greater distances, we find isolated genera of another group. We have to account for the separation of members of the same species by sea and for the occurrence of unlike species in different parts of continuous areas of land. We have to account for the amount of difference which the northern and the southern forms exhibit; and no less for the amount of resemblance which they present.

Suppose we attack, in the first place, the problem of the existence of the same species of cray-fish, *Astacus fluviatilis*, in England, in France, and in Germany. I do not imagine that any one who has paid attention to the subject has much doubt as to how that has come about. The British Islands stand upon a sort of plateau of the European Continent, which gradually shoals out into the Atlantic, and an elevation of five hundred or six hundred feet would bring us into continuity of dry land with the Continent. There is abundant evidence of very various kinds that this dry land connection once existed—that, in fact, Britain and Ireland were, at one time, a mere peninsula of Europe, jutting out into the Atlantic; and at that time, no doubt, by migration from the mainland, all those forms of life which we find in the British Islands which are unable to swim across the ocean, and which are identical with those in the mainland of Europe, extended from the one area into the other.

*Astacus fluviatilis* may have spread along with the rest, and when the depression which cut us off from the main land of Europe took place, the immigrant cray-fish population would be separated from the continental stock. In this way the isolation of the English cray-fishes is accounted for, in the simplest possible fashion, by the fact that the intermediate land has undergone depression. Pray understand that I am not now inventing an hypothesis to account for the facts, but simply mentioning an event which is known to have occurred on independent grounds, and which plainly accounts for the facts of distribution. Suppose that this subsidence were to go on and involve more and more of western Europe, you might have any amount of separation between the *Astacus fluviatilis* of Britain and the *Astacus fluviatilis* of the mainland. You will observe then that some of the most important difficulties of geographical distribution are at once got rid of by introducing the idea of geological change, that is to say of the alteration of the level of the land and the changes thus produced in physical geography. That process may cut up an area, inhabited by any given species of animal, into two, or into many portions separated from one another by indefinite areas of sea; and so far--to come back to the point I mentioned some time ago—so far, the existence of identical species upon opposite sides of the English Channel is—to read it back the other way —evidence of a previous geographical condition, that is to say, of the connection of Britain with the mainland. So far, the facts of distribution are monuments of the changes which have taken place in the physical geography of the globe. The like reasoning applies to the case of the Japanese islands, which are situated upon a submarine plateau of eastern Asia.

Next comes the question—How are we to account for different species in adjacent and continuous land areas? With some qualification, it may be said that, everyone of these great hydrographic basins has its own kinds of cray-fish. Here there are two kinds of explanation open. The one possibility is, that the primitive form from which the cray-fish may have been derived, and of which I will speak directly, may have entered these different river basins at their embouchures, and may have spread over the whole river basin; or, on the other hand, it may be, that the whole of this vast area of northern Europe and Asia having formerly been occupied by one species of cray-fish, by a process of variation and of the preservation of varieties which take place in well known ways, what we call the different species of cray-fish have gradually arisen out of the one primitive cray-fish stock. And I must confess that I see no way of accounting for the extraordinary diversity of cray-fish forms which are met with in the basin of the Mississippi, except the supposition that, whatever was the primitive form, it has become modified in different river basins by their different climatal and other conditions, so as to give rise to these slightly different species and varieties. And I should say the same thing in regard to these two genera *Cambarus* and *Astacus*. They are in all respects so very closely allied that *Cambarus* may be regarded as *Astacus* with its hindermost gill suppressed, and with some minor modifications; and I should see no difficulty whatever in the derivation of the whole of those forms which are found in the Northern Hemisphere, from some one primitive form of cray-fish. And not only do I see no difficulty in the way of such an hypothesis, but the more I think of it the more difficult it appears to me to be to form any other conception of the manner in which these facts of geographical distribution have arisen.

Let me point out another very curious fact; it is, that this great area of Eurasia which lies north of the plateau of central Asia, is not only peopled by cray-fish, which all belong to the same genus *Astacus* but that there is a similarity in the character of its *fauna* throughout. Many animals inhabiting widely distant parts of this area are of identical or very similar species; so that there are multitudinous striking resemblances between the fauna of the British Islands and the fauna of Japan. The whole of this region is, in fact, what is called one of the provinces of distribution, one of those great areas of the earth's surface, in which there is, speaking broadly, a more or less uniform population, different from the population of other parts of the globe. It is termed the palæarctic regions. North America, north of Mexico, again, has a characteristic fauna, in many respects similar to that of the palæarctic region; but the animal population of this "nearctic" region west of the Rocky Mountains is, to a great extent, different from that of the east side of the range. The cray-fishes east of the Sierra Nevada are different from those of the west coast; and all the North American cray-fishes appear to be specifically, while the majority are generically, different from those of the palæarctic region.

Hence, it seems probable that, in the northern hemisphere, whatever causes have determined the distribution of land animals generally have operated upon the species of cray-fish. In the southern hemisphere on the contrary, there is no such correspondence between the distribution of terrestrial animals in general and that of the cray-fishes. Australia, New Zealand, and South America differ as widely in their terrestrial faunæ as any three provinces of distribution that can be named; but they are tenanted by cray-fishes which are as closely allied as are *Astacus* and *Cambarus*. On the other hand, there are some very curious points of resemblance between the distribution of the fresh water fishes of these parts of the world and that of the cray-fishes.

It is probable, therefore, that in the southern hemisphere, the distribution of cray-fishes and of fresh water fishes has been determined by conditions quite different from those that have determined the distribution of land animals; and there is no difficulty in understanding why such should be the case, if we bear in mind the fact that the inhabitants of fresh water may have had very different origins. Some are certainly terrestrial animals which have adopted an aquatic life, but others are marine animals which have taken to fresh water. There is every reason to believe that the cray-fishes belong to the latter category. I have no doubt that the cray-fish, like all the crustaceous inhabitants of fresh water, is a modified marine animal; that the stock from which it proceeded was originally, like the lobster and the prawn, an inhabitant of the sea, and that it has simply entered the river basins, and has there made itself at home, flourished, and taken possession of the ground. This may seem at first to be rather a strong hypothesis, but, in truth, there is abundance of analogical evidence in its favour. Prawns are especially marine animals, and they occur in the sea all over the world; yet there is hardly one of the great rivers up which prawns do not ascend sometimes, even to the head waters. A prawn, which is at the present time an inhabitant of the Mediterranean, is nevertheless, to be found in abundance in the Lago di Garda, completely shut out from access to the sea. There it is, living perfectly well, maintaining itself, and continuing its species; so that there is no doubt whatever that marine *Crustacea* may adapt themselves to live in fresh water. But if you ask me whether any marine form now exists which may be regarded as the immediate progenitor of cray-fishes, I know of none. There are many singular peculiarities about the cray-fishes which are not exactly repeated in any existing form of crustacean life in the sea; and their progenitor, whatever it was, is very probably extinct. But then, if we go back into the history of past times,—if we study the animals which are now contained in the fossil state in rocks, forms allied to the lobsters and cray-fishes are abundant; and there are some which may, by possibility, represent the original marine stock, though I cannot say positively that any one does it.

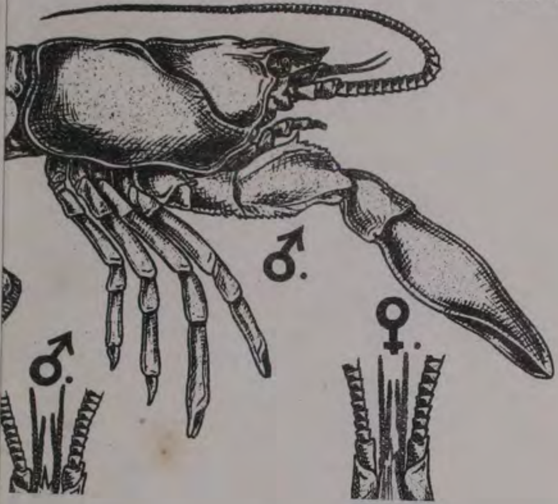
Thus, to put all the facts together, the view which I take of the matter is this; I conceive that at some time, far back in the world's history—I cannot pretend to say whether in the tertiary or in the secondary epoch, or at what time,—though we know certainly that animals very closely allied to cray-fishes lived in the sea in the secondary epoch—a marine ancestor of the cray-fishes was as widely spread over the world as the prawns are now; and that, just as we find in many other animals with a very wide distribution, so the northern and southern forms diverged from one another, in consequence of being subjected to different conditions. I suppose that the northern group gradually assumed the characters of *Astacus* and *Cambarus*, while the southern forms took on those which distinguish *Parastacus*, *Chœraps*, and other genera of the southern hemisphere. It may further be assumed that these animals were better fitted than their neighbours for fresh-water life. And I am strongly inclined to think that the circumstance which made them more fitted was the power of living more or less on vegetable food, which is not common among the *Crustacea*. I conceive that the cray-fishes, finding themselves better fitted than their contemporaries to deal with fresh-water conditions, ascended all the rivers which were accessible to them. And, in the northern hemisphere, I take it that they must have thus migrated at some time after the commencement of the elevation of the great table land of Central Asia; because if that had not been the case, I do not see why these cray-fish should have been debarred from getting beyond it. On the other hand, I suppose that the southern cray-fishes must have entered the river basins of Australia, of Madagascar, of the Fijis, of New Zealand, and South America, and must there have made themselves at home in the same way.

Thus, by taking into consideration on the one hand the changes which have been brought about in physical geography, by geological changes, and, on the other hand, the gradual modification of species in time, one is able to give a probable account of the manner in which these apparently anomalous and capricious facts of distribution have been brought about.

At the same time, I must point out to you what you will doubtless have seen for yourselves—that the hypothesis, though it helps us to understand why cray-fish exist in certain localities, does not explain their absence in others. Why it is that southern and south-eastern Asia and Africa should be entirely devoid of cray-fishes of either type, remains a mystery. It is not obvious, since there are cray-fishes in Madagascar, why they should not also have entered such rivers as the Zambesi, the Euphrates, and the Indus. It may be that the key to this puzzle lies in changes of physical geography of greater magnitude than there is any present warrant for assuming. Or it is possible that, in the struggle for existence in these regions, the competition of fresh water prawns and fresh water crabs was too severe to be withstood by cray-fish, which were thus excluded from the rivers to which the former had obtained access. No part of geographical distribution has been more neglected than the study of the Crustaceous fauna of the rivers of remote parts of the world, and I recommend it to your attention.

I hope that I may have succeeded in this very brief and imperfect sketch in pointing out to you that some very interesting problems are connected with, and arise out of, the facts of distribution. You see there is no one of them the explanation of which can be attained without the application, in the first place, of the greatest of all biological hypotheses of modern times—the doctrine of evolution; and without, in the second place, taking into account one of the most important conceptions with which modern geological investigation has familiarized the mind; I mean the notion of the incessant change in the configuration of land and sea brought about by alterations in the level of the crust of the earth. But the first and most important matter is to get at the facts, and what I have endeavoured to point out to you is, that many who are here present may, in the course of their future career, have the opportunity, without going through the toil and trouble of a special biological education, of contributing some of the data which are necessary for the solution of the problems of geographical distribution.

Plate I.



# PAPER II.

## INDIAN SYSTEMS

OF

# GEOGRAPHICAL MAP-MAKING.

By Captain T. H. Holdich, R.E.

*A lecture delivered at the R. E. Institute, Chatham, on 10th October,* 1878.

Of all the nations of the continent of Europe, two only have lately been engaged in geographical operations of a nature that might serve to give us valuable technical information in the particular branch of geodesy, which we call geographical surveying. France has been engaged in such work in Algeria, and Russia in Central Asia, and an examination of the systems of geographical surveying which they follow would doubtless be of very great interest—of great interest, but of little value, for there is this difficulty; in dealing with any foreign system as a source of information to guide us to sound conclusions, every system of mapping (like most systems in general) must be judged to be either good or bad by the excellence or otherwise of its results. But in dealing with French or Russian maps we have no guide whatever to their accuracy. We have obviously no power to apply a check or to sit in judgment on them, and consequently no power at all to say that their system of map making is either better or worse than our own. The most careful examination can lead to no definite conclusion, nor, speaking generally, can we say that what we know, and have known for years of foreign systems has in any material degree assisted to modify or elaborate our own system of survey. In fact, just as no nation has anything like the large interests that England has involved in this branch of science, so England also has the largest experience on which to base a scientific system of topography, and to our own surveys we naturally look to give us the guiding lines for its future extension. But this same difficulty of rightly estimating the value of maps applies to our own maps and our own systems. How are we to decide on the abstract value of any map? Having said of a map that it is accurate and highly artistic, it is quite open to any one else to say that it is inaccurate and most inartistic, and, indeed, this not infrequently happens even in scientific circles. What are the causes of fault in the matter? In the absence of public criticism, where is a fixed standard of excellence to which we may refer?

This is certainly a difficult question, but it seems to me that there are three guiding lines, three conditions or points of departure, as it were, from which we may proceed to adjudge the value of any map about which we can get full information. These three conditions are as follows:—What time was available for its construction? What did it cost? How far is it accurate? And relatively to these points we may either decide in the abstract that a map is good or bad, or we may bring any two maps together and say of one that it is better than another, and so, by means of the map, come to a similar conclusion in respect to the system under which it is produced.

And it may be pointed out that these three principal conditions serve a great deal further than mere points of reference to decide the value of a single map. They govern, one or other of them, every system of map-making under every government in the world. If I say that accuracy is the guiding principle of our ordnance maps of England, I shall be sufficiently expressing the sentiment of every one here, without going into details to show the labour and time that is involved in their construction, or to prove that they cost per square mile 15 times as much as the ordnance sheets in India. It is enough to say that they are probably the most accurate maps in existence. Again, in all systems of work adapted to meet the requirements of field service, time fixes sharp limits of the work to be accomplished. To conduct survey operations in company with, or under cover of an advancing field force is one long struggle against time, as anyone must bitterly feel who has taken part in such operations. In India, again, the normal maps of the country are constructed as quickly as may be possible, and as accurately, consistent with a certain fixed expenditure for the whole department. Economy is certainly the guiding principle of Indian surveys, and we consequently find in that land, where salaries are necessarily high and carriage always costly, that maps are yet turned out considerably cheaper than in any continental system.

In looking at any map then, it is necessary to bear these three conditions in mind, or we may fall into the error of condemning a reconnaissance because it is not a survey, or an excellent geographical map because it will not tally with an ordnance sheet. Simple as they are, it is by no means unnecessary to insist on their recognition. Very unhappy has been the effect of a mis-apprehension of them even lately in India.

In looking to the future we must first decide on what are the probable conditions under which geographical maps will have to be made. Speaking generally it may, I think, be taken for granted that we shall have wide areas before us of rough uncivilized country, of which a knowledge of the leading features will be firstly valuable from a military point of view.

Time, which means rapidity of action, will be the guiding principle of these first surveys. Short and sharp are the military expeditions of the present day, involving hard marching and quick results. There will be no time to deliberate on the best system of work when that work has once begun. To get all the information one can in the readiest way one can, to turn to the best account small opportunities as they offer themselves, while retaining a general settled system of work which must be capable of much modification—a pliant system as it were—are the requirements of a modern military survey, to produce any definite results when the campaign is over. But looking a little farther into the future it is not difficult to foresee that beyond these first requirements there will be very large tracts of country, over which some more exact survey must pass than is sufficient to fulfil the purposes of a military reconnaissance, and which will be executed with none of the urgency of military movements attending it. Such a survey, in fact, as is now being carried over the native states of Hindustan, and which is extending itself even beyond our frontiers; such as has already been found wanting in Cyprus, and may possibly be very urgently wanted in Asia Minor; such as will most assuredly be required for the highlands of the Transvaal, and must extend itself with the tide of progress in our Australian colonies; and which even may, in a future which we may yet live to see, be spread in some modified form over those interesting countries which have only lately yielded up the great secret of the Nile.

But the urgent requirement of such a survey is usually a long way in advance of the means to pay for it. It frequently happens, indeed, that it is only through the agency of such a survey that the money producing capabilities of a country can be justly estimated. It is frequently so in India, where the surveys of the native states are made at imperial expense. A useful, sound, geographical map, shewing cultivated and cultivable areas, roads, rivers, villages, and valuable forest land, becomes a necessity to the civil administrator of a district, long before there is even a promise of recoupment of the expenses incident on making it. The guiding principle in the construction of such a map is, evidently, economy. It must be made as cheaply as possible, consistently with such a degree of accuracy as may insure its value in assisting the administration of government, or the assessment of revenue.

In considering the value of different systems under which such maps as these are produced, I think, for the present at least, we shall get the largest amount of information from our Indian surveys. Other countries besides England have had to carry geographical surveys through other lands than India, but the means are not forthcoming, as has already been stated, to enable us to estimate rightly the relative value of their maps, nor do such maps as are within our reach bear internal evidence of a higher degree of accuracy under similar conditions of time and cost than do our own Indian maps.

Moreover, the varied surface of India seems to present special advantages of study of almost all characteristics of topography that are likely to be met with in the great unmapped world. India presents every variety of physical aspect, except that which is most familiar to us in England and Europe, of the most highly cultivated tracts supporting large manufacturing towns—and this, it is hardly necessary to observe, is just what geographical surveyors are never likely to deal with.

We may as well then, at once, begin with an examination of our Indian system of map making, and see wherein it differs from what is generally accepted as the English system, taught in our Military Academies and at Chatham.

Now the Indian system is so simple that, with hardly an exception (the exception will be noted afterwards), all classes of geographical surveying may be summarised in a very few words as—*plane tabling based on triangulation*. It may seem odd that such a well known old surveying instrument as the plane table should not, even yet, have arrived at the point of due appreciation. Used by every European country except England, and used by Englishmen most largely in India, it seems difficult to account for the fact that in England alone its scientific use is practically unknown. Of course, I am aware that it is occasionally used as an adjunct to a prismatic compass, or some other angle observing instrument, but this is not what I mean by the scientific use of it, and I think I am justified in saying that its capabilities as a scientific instrument are practically unknown. It is due to the memory of one of India's most able Engineers (Colonel Dan Robinson, who lately died at the head of the Telegraphic Department of India) to say that it was his foresight that first pointed out the use of the plane table for Indian surveying. In it he found an instrument so simple that any intelligent native could readily be taught to use it, an angle observing instrument far exceeding in accuracy the prismatic compass, and a traversing instrument of the greatest value, from the fact of its being totally independent of compass error induced by local magnetic attraction; it has been in use now for many years, during which many officers have learned its capabilities while employed in the survey of our great Indian dependency. As each one, in turn, has been introduced to the system, he has admitted its value to be greater the more thoroughly he has become acquainted with it, so that of every officer in the Indian Survey Department, I think it may now be said, that, were he asked how he would propose to make a map of any rough piece of country before him from a geographical survey to a rough military reconnaissance, he would unhesitatingly reply, "Let us plane table it." There is not one, no matter how he may have been originally taught, who would adopt any other method.

Now any system which inspires such general confidence as this, is surely worth attention at present, and a fair trial in those large and important fields of work which yet lie before us.

The normal system of Indian surveying is as follows, the system being only modified to meet the necessary requirements of time in the case of military expeditions. The ground is first triangulated from an efficient base, which base in India is invariably furnished by a side of one of the great trigonometrical triangles which are extended in longitudinal and meridional series over the face of the country. Even in the case of our military frontier expeditions such a base is generally procurable—but we must deal with such surveys as forming a distinct class. The triangulator who uses a 10" or 12" theodolite will usually take a plane table with him, and carry on a geographical reconnaissance hand-in-hand with his angular observations. If time admits, he passes over the ground first with the plane table, previous to any instrumental triangulation whatever, as it is in this way that he can best assign, first, the proper position and proportion of points which are to form trigonometrical stations, and next, the subsidiary or secondary points which are fixed by three or more intersections; and can detail the necessary working parties for clearing jungle and erecting signals. Now, though this is merely a rough triangulation chart, its use, when the instrumental work begins, in pointing out the approximate position of signal stations, and in defining the field in which to search for them, when in a background of forest and hill they would often escape detection even with the most powerful instrument, is enormous, and the surveyor will often be surprised to find when the final computations are elaborated, and he is able for the first time to plot accurately by latitude and longitude the position of his trigonometrical stations on his plane table, how accurate this reconnaissance, carried out with no aid of compass or protractor (both of which introduce their own class of error) proves to be.

But it not infrequently happens, as I have said, that from the excessive wildness of the country and difficulty of moving about in it, it is most unadvisable to pass over any of the ground twice. The erection of many signals becomes an impossibility, and the selection of trigonometrical stations even a matter of great difficulty. Under pressure of time it becomes necessary to triangulate without any previous reconnaissance whatever. In a country presenting no other features than forest clad peaks, rising with painful similarity of feature and monotony of colour from dull forest clad plains below, where the highest tree that may show its top somewhat above the level of those around it becomes the only available signal from day to day through trackless miles of interminable jungle, it would be totally impossible without a plane table chart of this description to unravel the recorded observations to hill peak after hill peak, and finally place each in its proper position. And we must expect much of such work as this in future. Into the details of triangulation and the nature of signals it is impossible for me to enter. I will merely add that true economy of time and labour consists in carrying a triangulation, once commenced, right through to its completion—never passing twice over the same ground, never revisiting a station once occupied. To attempt first a bit of triangulation, and then a bit of topography, or to carry on the two together, hand in hand as it were, over the same ground, will never lead to a large out-turn of work. The reasons are obvious, but the effect is best noted by the fact that though it would be possible by making steady and direct progress through even the worst country to triangulate, say 4,000 miles in 10 weeks to three months, yet it would never be practicable to do 400 in the first week of the 10. I may further state that all such triangulation being for the subsequent use of plane tablers, we find that one trigonometrical point for each 70 to 100 miles—and one secondary for each 10 square miles is ample for 1-inch work, or about half of what would generally be considered sufficient for topography by any other system of fixings by interpolation.

Neither in India, nor elsewhere in country similar to India, is it necessary (in fact it is not possible, consistently with our guiding principle of economy) to employ only highly skilled labour for the purposes of topography. It is true that a proportion (varying in different districts with the peculiar difficulties presented in the course of survey) of every survey party must consist of skilled draftsmen, who have sufficient mathematical capabilities to enable them to compute ordinary triangulation, during the season when the climate interferes with the field work, and who complete the final mapping by making fair copies of the field sheets; but if the superintending officer is prepared to compute his own observations, his draftsmen might be draftsmen and nothing more. Given that a man has a capability for drawing, (a capability which most natives of India possess more or less), he is at once suited with an instrument in his plane table, which enables him to take his place as a surveyor at the minimum cost of expense in teaching. He need know nothing about angular measurement; he need not be able even to read a compass; he never has an observation of any sort to record. The system of fixing his own position by interpolation by the simple process of looking through the sights of his ruler, is one which commends itself to the most ignorant mind for its very simplicity. If three rays intersect he knows he is right (there is just a possible exception to this), if they do not he is wrong, and all he has to learn is which way his table must move in azimuth to correct the azithmuth error and bring the rays together to a point. It is usually the practice to make use of the compass to get the approximate azimuth in the first instance, but the true azimuth is determined, not by it, but by the due intersection of rays. And it must be remembered that this intersection can be made as minutely accurate as it is possible for a pencil point to define it.

Those accustomed to the system of mapping from points fixed by interpolation from prismatic compass observations will remember that there are four distinct origins of error in the system. Firstly, the compass error induced by local attraction. With this error, so far as I know, it is impossible to deal, although it must have fallen within the experience of every geographical surveyor to have found himself often in positions when his compass was absolutely useless. I confess I do not know how this difficulty has been overcome, but it would, in some parts of the world that I have been in, prevent map making on this system altogether. Secondly, there is the error of compass observation. To what degree of accuracy can an observer take an angle with a prismatic compass? I think 20′ is probably near the mark. Thirdly, there is the error of a graduated protractor. Assuming that a circular machine-made brass protractor is used, the average error (I have tested many) is about 15′. Ivory protractors are so absolutely useless from this source of error that I presume nobody uses them. Fourthly, there is the error arising from inaccurate protraction of the observed ray, an error (whatever may be its value) that is proportionate to the length of the ray or line protracted. When this line is finally laid down in the sketch sheet, within what limits can the surveyor guarantee its final accuracy? Shall I say half a degree? I think a degree would be much nearer the truth. And if three such protracted rays do not intersect, to which error of the four must the divergence be assigned, and what is to determine the relative value of these rays? It is clear that fixed points from which to interpolate must be close to the observer, and there must be many of them, from the tendency to increase of error with the length of the ray. And if we fix a limit of distance beyond which no point should be used, the triangulator must remember that the number of points he has to lay down increases in an inverse ratio with the *square* of that distance. Now an average plane table for 1-inch survey work contains about 450 square miles, or for geographical reconnaissance on the $\frac{1}{4}$-inch (a very useful scale for this sort of work) 450 × 16, or 7200 square miles of country. And if in all this vast area there be four fairly well placed, easily recognised, fixed points previously laid down, which points need not by any means necessarily be visible from every point of that area—but only from positions of important elevation within it—there is quite sufficient means for the topographer to commence his map at once. The four origins of error are reduced to one. There is no compass error, as there need be no compass. There is no protractor either, but there is one source of error in the angular accuracy of the actual observation through the ruler. The value of the plane table as an angle observer has been variously estimated at from 5′ to 10′. I am inclined to put it at 5′. 10′ subtends 15 feet at a mile, and a 15-foot signal would afford a very definite centre at that distance. Suppose the azimuthal adjustment to be slightly inaccurate, the intersection of rays from short distances would still be good, and the error unobservable; but as this error increases with the length of the ray, intersections from long distances would gradually become worse till the rays ceased to meet in a point. But the nature of the figure enclosed by them when the intersection fails, at once reveals the extent of the error, which can have but one assignable cause, and the correction is easy. This is why far distant points are used as references for adjustment in azimuth, while it is found advisable to have, if possible, a fair number of points scattered over the board to prevent the loss of time occasioned by the necessity of very fine adjustment. The accuracy of the plane table has been defined as limited only by the fineness of the point of a hard pencil. Compared to the prismatic compass as an angle observer, I should be inclined to reckon it in the ratio of 5′ to 40′ or 50′. Nor must the advantage of working on a steady immoveable table, which is truly parallel to (that is to say in true azimuthal relation with) the country to be surveyed, be overlooked. It saves a great deal of troublesome thought and care; while the saving of *time* effected may be easily reckoned up by anyone who will compare the processes of simply observing and drawing a line on a level table, with that of observing with an unsteady compass, and then protracting, first, the angle and then the ray, in a cramped position on an equally unsteady sketch sheet.

Natives of all classes shew special facility in acquiring a knowledge of plane tabling, so that a very large share of the topography of India is now laid down by them, and for the future we must look largely to all such local agency in carrying out geographical operations at anything like a reasonable cost.

The nett result of the system is this: Admirable 1-inch maps are turned out, often of the highest quality in point of accuracy that is attainable in maps published on the same scale as the field sheets —and always of a good average in this respect—at $\frac{1}{15}$th the cost of the 1-inch ordnance maps of England, or about £2 per square mile. But it might fairly be doubted whether the plane table is suited to all classes of ground alike that are to be found in India, or that might be found in any country possessing about the same wealth of cultivated land. India offers us a large variety. There are large expanses of wide, sandy desert, with details of topography but sparely scattered through them, and many of the natural features shifting from year to year under the influence of climate. There is the normal condition of hill and plain, with a certain proportion of fine natural landmarks that have to be supplemented by auxiliary signals. There is much of flat and well cultivated plain, difficult to survey from its exceeding flatness, and the preponderance of large trees in clumps, or *topes*, and lastly, there is *very* much of wild jungle-covered country, nothing but rank growth of forest trees and forest grass, where one may ride for many a day's journey without finding a natural landmark of importance, and where every artificial signal has to be hunted for. How are we to deal with country such as this without reducing the value of the survey to that of a mere reconnaissance, or without increasing the cost to excess by clearing lines of traverse and points for interpolated fixings. The experience of the last few years has taught me that this is a very difficult problem, but that it is best solved, after all, by the use of the plane table.

I need not explain in detail all the different systems of traverse, but that is, perhaps, best by which the traverse is laid down down on a large scale, on a sheet of paper pinned down over the board, and projected (after reduction to the proper scale) at intervals into the map, whenever any opportunity for check by direct observation to any station or signal on its flank may occur. Traverses may be made to converge to a point, or to "gridiron," and so check one another. Every check that can be gained is brought into play at once, and its effect noted on the ground. Errors of chain measurement are generally detected almost as soon as they occur, and on the whole this system of traverse work may be said to be very fairly satisfactory. So that in all circumstances, and in every class of ground, plane tabling may be classed as the very backbone of Indian surveying.

But having so far described what is done in India, it would be most instructive to examine what has been done by English surveyors elsewhere, under similar conditions of time, cost, and accuracy; such as may guide us to a relative appreciation of the respective results. A certain amount of topographical work was executed in connection with the North American Boundary Commission, but its execution, in the matter both of time and cost, was so entirely subsidiary to the boundary definition, that it seems impossible to separate the two classes of survey. As it was, moreover, but a narrow strip of country, extending nowhere more than a few miles from the boundary which furnished its basis, it does not present an example of so much interest as others that we can find.

The survey of Palestine, which has been conducted during several years by Royal Engineer officers, and worked by Royal Engineer draftsmen, is, under all its conditions, more nearly similar to the geographical work in India, and gives us a more instructive example, because, though of small extent, it has been large enough to test fairly a definite system. With regard to any remarks I may make on this survey, it must be understood that I am indebted entirely to the kindness of Lieut. Kitchener for any information which I possess, and that such remarks refer only to that part of the work which has been conducted by him. But Lieut. Kitchener's party included some fairly experienced hands, who might be supposed (as I feel sure was the case) to realize the best possible out-turn. The scale of the work is just that of the normal Indian Survey. The object aimed at was finally the same, though there was probably much work, extraneous to the simple surveying, in archæological and other scientific examinations of sites, and in various reports, for which due allowance must be made. The ground was easy to survey —as I believe is the case throughout Syria. I should have thought it was very easy, but for the assurance to the contrary of those who mapped it, and who ought to know best. But here again we come to the necessity for a definition, and I can only appeal to the decision of those here who may happen to have worked in India, as to the nature of the ground. It is generally open, with here and there strips of sandy plain, almost amounting to desert in their characteristics. There are no forests of any great extent, nothing of the nature of what we generically term "jungle." The face of the country consists partly of hills of tolerably abrupt conformation, and partly of open plain, here and there much cut up with ravines. There are such numbers of natural landmarks that the triangulator laid down about six or seven times as many points as would be furnished in a similar area in India, without ever clearing a ray or erecting an artificial signal. It follows, of course, that nowhere could the topographers well put themselves out of sight of three or more such points. Finally, I think I am correct in saying that the topographers could ride to their work over pretty nearly the whole area. The difficulty possibly lay in the amount of detail which (although the final maps shew no excess) may have led to confusion in the selection of the most important features. On the other hand, in Sir Rutherford Alcock's address to the Royal Geographical Society last May, we find, with reference to Indian Surveys and to the work of Lieut. Harman, R.E., in particular, "The work was very difficult, incessant rain for many days not only flooded the nullahs and turned the forest paths into streams of mud and water, but brought out myriads of leeches, while cane jungles formed almost insuperable obstacles to laden elephants. Lieut. Harman found magnificent specimens of rubber trees, and in one of them a trigonometrical station was formed, 112 feet above the ground, to connect his triangulation with that of Lieut. Woodthorpe, R.E. Lieut. Harman was laid up, &c."; and of Lieut. Woodthorpe's work he says "In one place a range of hills is described as 'nearly level along the top, with no commanding point anywhere, it is sinuous and covered with tall forest trees filled in with a tangled undergrowth of bamboos and canes, through which we cut at the rate of 300 yards an hour.'" And again "The survey of the river was difficult." In some places "it took three horses to make a quarter of a mile of way," and so on. There is plenty of such work in India; but we see, at any rate, that there must be wide distinctions between different classes of country, and I think we may fairly call Palestine comparatively easy. As to the time occupied and the cost of the field sheets (not of the *final maps* please observe) of the survey, it appears that about 1000 square miles were surveyed between the end of February and the 10th July. This I make out to be about $18\frac{1}{2}$ weeks, and would give an average of about 18 square miles per topographer (for three men) per week, if we leave the topography done by Lieut. Kitchener himself out of account. He could, at any rate, have only devoted a part of his time to the mapping, and we shall get a fairer average, perhaps, by leaving it out of account. The estimated cost was about £900 for that amount of field work, or about 18s. per mile. So far as one can judge from what must at best be only an approximate estimate, topographers of about the same technical skill as draftsmen would turn out a considerably larger area in similar ground in India. I must speak from my own experience only, if I say that 25 to 30 miles would be expected of them. As to cost, if we estimate the cost of the field sheets only (which is what we have at present to deal with) I think we should find the cost of the Indian Survey somewhat greater, say from £1 to 25s. But it must be borne in mind that the salaries of Indian surveyors range from £60 to £600 per annum, and the salaries of the superintendent from £600 to £2,000, or more; while the conditions of cost must otherwise be so widely different in the two cases that we can institute no fair comparison, and must appeal finally to the test of accuracy. This is a difficult matter to deal with, and it might be fairly said that only a comparison of the field sheets of the respective surveys by competent critics could decide anything, and much do I regret the impossibility of procuring the field sheets at present. I must emphasize the fact of the field sheets affording the only safe and practicable guide in the matter, and emphatically assert that the final maps as reproduced by photozincography, afford no criterion whatever. But still there is a test of the value of such maps, one constantly applied in India, and held to be, in the main, satisfactory, and this is the record of the number of interpolated fixings of his position made by the topographer in each square mile. I am very far from saying that this is a perfectly unerring guide, nor do I quite agree with a high authority (perhaps the highest) in India, who unquestionably condemned maps of a hill district, of which he admitted the high artistic merit and apparent consistency of detail, because there were only one or two such fixings per square mile; I can conceive that in that case those one or two were sufficient, but still this is, in the main, a satisfactory test, quite applicable in the case before us. This average in the Palestine survey, I was told, (but I think that careful examination might alter the figures) was about two per mile, which would, on such ground, be considered hardly sufficient in India to complete a fairly accurate reconnaissance. This is just what I understand the Palestine maps claim to be—a reconnaissance of the ground between the Jordan and the Mediterranean. But we most distinctly claim for our Indian 1-inch maps that they are not reconnaissances at all, but surveys, and we should require an average of at least six or seven (rising perhaps to ten) fixings per square mile, for a country such as that to be as accurately sketched in detail as the scale will admit. And this conclusion is just what I should expect. *Ceteris paribus*, a man using the plane table would certainly be able to fix his position twice as often and sketch twice as much—with far more accuracy—as the man who has to observe each angle with an unsteady compass and protract it with an inaccurate protractor on a shifting piece of tracing paper. Yet another point in connection with the Palestine surveys may be stated as furnishing some indication of the general style of survey turned out by the use of the prismatic compass. Whole villages (without any definite point in them) were found to answer the purpose of signals, or fixed points for observation. I can quite imagine this to be so—but it would not do to offer such a point to a plane table workman—from what has been said it should be clear, I think, that the difference between the two systems, as illustrated by such results as we have been able to get at and compare, amounts to this—the plane tabler will effect a survey where the prismatic compass observer will produce a reconnaissance, and I think such a conclusion represents the situation pretty accurately. It may be said that the reconnaissance is all that is wanted—that it is quite good enough. No map is good enough that could have been much better for the same cost, or that might have been done on half the scale in a quarter of the time with the same amount of accuracy.

We will next consider our Indian system of map-making as applied to the work of a reconnaissance—a field map executed in conjunction with an army in the field under stringent conditions of time. I need not enter into details of the circumstances under which such maps are usually made, but it should be remembered that the time available for such work is usually but a small part of that occupied by the campaign or expedition, as the work of the surveyors must almost always be abandoned on the backward march of the troops from the furthest point gained by the advance, as it is only under cover of an advancing force that commanding points for observation can be occupied, and it seldom happens that surveyors can be allowed to remain behind, or even far from the main column. Time, again, is limited by accidents innumerable, which are certain to arise to cause delay and bar the progress of the work. The importance of being early in the field is very great. The surveyors should be on the ground as soon as they can obtain a footing, as there are casual opportunities of gaining valuable information at the commencement of the campaign, which may never occur again. At present the information gained by the preliminary reconnaissances of the officers of the Quarter-Master General's Department add little or nothing to our geographical knowledge, but there is no reason why it should be so, were those officers invariably acquainted with the use of the plane table.

It is, indeed, most especially in this branch of the surveyor's art (that of military reconnaissance) that the value of the plane table is most strikingly illustrated. Indeed, we may say, that it is only the introduction of the plane table system that has, at last, put into our hands the means of acquiring that wide spread and thorough military geographical knowledge which modern science demands. Never again can there be an excuse for turning our backs on a country without such a complete and thorough knowledge of it at our disposal, as shall definitely guide the course of all future campaigns. It is no small thing to reduce to a scientific map the grand chaos of mountain and valley, that bewilders the eye and depresses one with the sense of endless confusion, at the first glance over the mighty northern mountain chains of India, when the only basis for the map are some four or five widely scattered snow peaks whose cold sides defy all human approach. And it is no small system that will help us to do it. The prismatic compass cannot help us here. We must have a broad sheet before us representing at one view many thousands of square miles, or we shall be unable to make one of the few points which are all we can get. We must have the power of minute accuracy to enable us to reduce the scale sufficiently to get those thousands of miles into a portable board. We must have perfect steadiness and no variable compass on those iron hills.

The system which has stood the test of severe trials in India, and promises best towards further developing this branch of science, is but a modification of what has already been described—"plane tabling, based on triangulation."

All along the western and northern frontier of India from Afghanistan to Bhootan, a number of out-lying points have been from time to time laid down by triangulation from within the frontier, comprising peaks of the great Himalayan chains, conspicuous by reason of their height or form, so that it is only necessary for a surveyor to determine what must be the scale of his map, so that, on a plane table of the largest dimensions compatible with portability, he may introduce five or six of such widely scattered points within the limits of his board, for him to have, at once, a practicable, if not always very adequate basis for topography. Bare measurements and preliminary triangulation thus disappear, and a great advantage is gained by working on a plan which embraces a large area of country, which advantage increases with the number of points thus secured within its limits. This is no new system. Admirable maps have thus been made by Colonel Godwin Austen, of the Bengal Staff Corps, and Captain C. Strahan, R.E., and later by Lieutenants Leach and Woodthorpe, Harman and Major Badgley. Such work is constantly in progress, and in this way we are gradually extending our geographical knowledge beyond our Indian frontier, and shall, doubtless, eventually have a perfect acquaintance with that great debateable land which lies between us and the Russian frontier. The points, or peaks so fixed serve also as points of reference to another class of geographical surveyors altogether. These are the plucky native workmen who under various disguises penetrate into the dreary steppes of Thibet, and bring back at the risk of their lives geographical records of countries absolutely closed to Europeans. This is, indeed, geographical map-making of another and most interesting type, which can hardly as yet be classed as reconnaissance; its high importance has been most fully recognised by the Royal Geographical Society by the award of its medals to Colonel Montgomerie, R.E., Captain Trotter, R.E., and last but not least to the gallant old pundit Nain Sing, native schoolmaster in the district of Kumaon, who may yet live long enough to stir up a rising generation to similar feats of pluck and endurance.

But it does not always happen that we can start with the advantage of points trigonometrically fixed as a basis for map-making of this sort. There are other countries than India equally worthy of the attention of geographers, which have, as yet, no absolutely fixed value of latitude and longitude, whose places on the world's surface may still be called indefinite. Such was the nature of things in Ashanti. I am not aware, though, what (if any) attempt was made to lay down a scientific basis for future geographers in that by no means unimportant corner of geographical *terra incognita*. It does not appear in Colonel Home's report. But the effort was made in Abyssinia, with results too that, in view of the new relations springing up between England and Egypt, and between Egypt and Abyssinia, are growing in importance every day. The line, nearly 400 miles in length, then accurately defined along the main waterparting of North Africa, between the Mediterranean and the Red Sea drainage, served as a base from which peaks were fixed along its flanks, which might even now be sighted from the furthest advanced points in the reconnaissance of the head waters of the Nile, laid down by officers under Gordon Pacha's command. The plane tabler could doubtless bring them together and bridge over a tract of most interesting country, which, at present, divides Egypt from Abyssinia, and that in a land where knowledge of the country means simply security of possession. There is no geographical knowledge in that portion of the globe that will not prove, at no very distant date, of the highest political, if not commercial value. The operations in Abyssinia had to commence with the measurement of a base; observations for absolute latitude, longitude and azimuth were taken at either end, with all the accuracy that the use of first class instruments would admit, the longitude being determined by observations similar to those used in the definition of the North American Boundary. Thus the whole of the work has an absolute value of its own on the earth's surface, which must be accepted as a satisfactory reference for that part of the continent, until observations of a still more rigidly accurate nature can be taken elsewhere in North Africa. From this base some preliminary points were laid down by triangulation, which gave the basis for topography from the sea-coast to Senafé on the high land, where another base and further triangulation carried it on to Antalo. The ends of the bases were connected by an instrumental traverse, which was run right through the entire route from end to end. A treble value by observations for latitude (the route being nearly north and south gave these a peculiar value) and longitude by traverse, and by plane table were thus secured, and it was found that the error by the plane table (on the $\frac{1}{4}$-inch scale) was so small as to be unapparent. A fresh base at Antalo and another at Magdala completed the triangulation necessary, but beyond Antalo the topography became thin and weak. The party was worn out, and there was not an officer with the force capable of using a plane table (though there were many whose services would have been available), and other methods failed miserably when brought to the test of actual practice, at the pace which it was necessary to maintain. In all, however, above 5,000 square miles of actual mapping, and about 400 miles of a traversed route, along the most important line that could have been selected with a view to the future extension of geographical work in North Africa, including the verification of much doubtful information supplied by previous travellers, was secured by three officers and one non-commissioned officer of the Royal Engineers, from the effective strength of which small party a large deduction must be made for sickness. It was a striking illustration of the value of the plane table, and we learnt from this expedition :—1st, that the route traverse might have been dispensed with, as only affording an additional check, and supplying no geographical information whatever; and 2ndly, that all this, and very much more than this, might have been easily accomplished without the expense of any special survey party whatever, had the officers of the Quarter-Master General's Department been well instructed in the use of the plane table. I have avoided touching on the question of the value of the geographical results thus obtained, either from the geographical or military point of view, because this value has been fully discussed before. Geographers will at once agree that all new information, whensoever and wheresoever obtained, has its value; and the effect of the various topographical features of what has been called the Earth's Crust on the conduct of a campaign, has already been treated with the greatest clearness in Hamley's *Operations of War*, and other standard military works. It is the best method by which to obtain a knowledge of such features with which we have at present to do.

I have also left untouched the question of the adaptation of the plane table to the work of ordinary military reconnaissance, beyond stating that any military officer of the Indian Survey Department would most certainly use the plane table for such work. But it is not the sort of work which has fallen much to the Department, and I should be wandering outside the realms of hard experience and fact into those of suggestion and theory, which I have no wish to do. *Rapidity and accuracy* appear to me to be as fully important in this branch of military survey as in all others, and the plane table would lose nothing by the additional capability of a contouring or levelling instrument for work on a larger scale. Possibly an objection might be raised on the score of portability. We are not in the habit of bestowing much consideration on this point in India. Our 24″ theodolites find their way up the steep sides of almost inaccessible peaks, and we have come to think very little about a pound or so more or less in the weight of an instrument. Consequently our Indian plane tables are not very portable. But a plane table is a drawing board on three legs, and it would be an insult to mechanical ability to suggest that it cannot be made just as portable as you please. Messrs. Troughton and Simms have just made one for me, which I could easily carry myself and, on the same construction, I have the satisfaction to find that it might have been made half the weight without in the least detracting from its value.

It is another class of map-making to which we must refer next. There may be weighty reasons (physical or political) which preclude the use of all instruments of the size and nature of a plane table. Where, for instance, observations have to be taken at the risk of life, and progress can only be maintained in secret and under disguise; here we are dependent on compass observations, on routes measured by pacing, on astronomical checks such as can be obtained with a small sextant. Even the pace of an advancing force (as in the case of the Russian advance on Khiva, in which the expedition under General Vereokin marched from Orenburg to Khiva, over 1,000 miles, between the end of February and the beginning of June, reaching Khiva at the same time as Kauffman's expedition from Tashkent) may be too great to admit of much more than this. But this sort of map-making is of, perhaps, the highest importance of all, both from its being within the power of every traveller to accomplish, and from its having lately developed to a remarkable extent by the employment of trained natives for Trans-Himalayan explorations. I think that the experience gained by work done in

India within the last ten years points to at least one consideration, which, if well weighed by travellers who aspire to the acquisition of a really scientific knowledge of the geography of the country they explore, might lead to valuable results. This consideration is the readiness with which all classes of natives, whose instincts have been sharpened and habits formed by the constant influences of nature herself and familiarity with her secrets, sieze on the main principles of map-making, and become, with a little pains in teaching, valuable aids to the acquisition of geographical knowledge. The general meagreness of the information supplied by most travellers is doubtless due to an over anxiety to be able to see and attest all geographical facts with their own eyes, added to the temptation of thrilling personal adventure, to leave alone the slow process of compiling the results of the observations of others. No one can wonder at this. Still there appear to be points in the progress of all great explorations at which the resources of the white man are at an end, at any rate, for a time. But what the white man cannot do, the native frequently can. He is apter at disguising himself, can support himself by ways and means which we know not, and, if at all accustomed to travel, can measure his paces through the long weary day with a persistency and accuracy that sometimes seems marvellous. Two men, started by different routes to the same point, and bringing back each his tale of paces, will lay down approximately the position of any such point, and if we add to this a slight familiarity with the use of the simplest instruments, such work can be done as you may read of in the reports of the Trans-Himalayan explorers during the last ten years.

Looking at the Transvaal with reference to the 600 or 700 miles of undefined country which lie between its frontier and the head-waters of the Nile—or at the most advanced posts on the Nile near Gondokoro, with reference to the debateable land between them and Abyssinia; or the marvellous lake region of which we hear so much, who can doubt that the man who first resigns the hopes and delights of personal adventure for the unpleasant process of shaping out a map from the observations of others, instructed and trained at that frontier, or at those advanced posts, will reap a rich reward of geographical knowledge. Another suggestion might possibly be of value. If every traveller, who keeps a chart of his travels, would mount that chart on a plane table, he would preserve it better, and would certainly at once double his capacity for adding to the topographical records of his map within any given limits of time. As he became more conversant with the use of the plane table, he would more surely find the thin red line across a blank sheet of white paper, which usually shews a traveller's footsteps, expand itself into something like a sound illustration of the topographical features of the country generally.

Briefly what I have endeavoured to show is as follows :—

1st. Systems of map-making must be judged by their results, of which the relative merit may be gauged by due consideration of the conditions as to time, economy, and accuracy under which they are obtained, and, as far as we can judge, the best results have been obtained under the Indian system.

2nd. That in all the vast field of mapping which yet lies before us, we are likely to arrive at the best results in the shortest time, and at the least expense, by a careful application of the main principles which have guided us to results in the survey of wild lands similar to those we are likely yet to find.

3rd. If we accept this as being, even possibly, true, then it follows that the use of the plane table should become general. It should not merely be an instrument in the hands of a few scientific men, but every officer who may ever be possibly called on to make a reconnaissance, or lay out a route should be thoroughly master of it. So far as the wide area of India, and its northern outlying states are concerned, the system is established, and it merely becomes a question of whether a man shall learn his work when he comes to do it for the first time, or have a previous knowledge of it, such as he would have of road or railway making, or barrack building. So far as this is concerned, it may be a matter of no vital importance, but there are times (is there not such an occasion at present?) when the knowledge of the system possessed by a few Engineers at our headquarters, or a few officers of the Quarter-Master General's Department, would be of the utmost value in the pressure of a campaign, when the burden of this, the most trying and severe work that a military man can engage in, falls upon the back of the over-strained Survey Department of India, when it may be that knowledge of the first importance must escape our grasp because there is no one to reap it. But there are other wide unmapped lands before us. Geographical discovery is the heritage of this age, and close in its footsteps follows geographical mapping. Would it not be well in England to make an honest trial of a well-established system—a system that has proved its strength—a system finally that has the unhesitating support of every single scientific man who has tried it.

T. H. H.

# PAPER III.

## NOTES ON THE

# PROGRESS OF GUNNERY.

BY MAJOR M. LAMBERT, R.E.

IN No. 3, Vol. I., *Occasional Papers*, Royal Engineer Institute, there was printed a very interesting lecture delivered at Chatham, on 31st July, 1877, by Major (now Lieut.-Colonel) Eardley Maitland, Royal Artillery, then Assistant Superintendent, Royal Gun Factories, Woolwich Arsenal, on the subject of "British Gunnery at the stage to which it was then advanced."

I wish that the subjoined notes may be read by those who may be interested in the subject, as a sequel to that paper, because, since that date, such progress has been made as to constitute what may be termed a fresh departure in the science of the construction of guns.

In the paper above alluded to, it is mentioned that velocities of 1600 feet per second, were beginning to be obtained with moderate pressures; and in Table C 1700 feet per second is shewn as the maximum velocity obtained with the new 12-pr. gun, then in an experimental stage.

Recently a gun has been constructed giving velocities of 2000 feet and upwards, and as from its success it is likely to inaugurate a new system in the proportions of the guns that will be made in future, a short description of it may prove to be interesting.

The new gun referred to is a 6-inch, or 80-pr., weighing only 4 tons, but firing a charge of 36 lbs. of powder. It is a breech-loader on the French pattern, as shewn with their sea service guns in the Paris Exhibition of 1867; the breech-block, which is in continuation of the axis of the bore being hinged back when open, the closing process being effected with what is termed an interrupted screw Thus far the system is French, but an important addition is made by fixing an expanding steel cup to the breech block, and this forms the base of the powder chamber when the breech is closed, and successfully counteracts any escape of gas. The gun has been constructed by the Elswick Ordnance Company, and has been carefully designed as an embodiment of the data obtained from the results of the complete series of observations made with the pressure and velocity registering instruments. It is considered to have actually performed ·75 of the task which was theoretically computed for it to do, and to have a fair margin of safety left.

With charges of 33 lbs. of powder, it has completely pierced a 10-inch iron armour-plate, both with chilled iron and Whitworth steel projectiles, at a distance of 80 yards, and has proved itself capable of doing with 36 lbs. very nearly as much, as an armour-piercing gun, as the 9-inch service gun, weighing 12 tons, and firing 70 lbs. of powder.

This result is obtained by a combination of chambering the gun to enable it to receive its large charge of powder, and lengthening the bore to enable the powder to be all consumed in the gun.

A comparison of the charges used in this gun, with those hitherto used, is very startling. (See Table I., List of Service Ordnance and Ammunition, published in No. 7, Vol. II., Royal Engineer Institute *Occasional Papers*, and Table C, accompanying Lieut.-Col. Maitland's Lecture, in No. 3, Vol. I., R.E.I. *Occasional Papers*.)

In the latter (viz., those with which the then considered high velocities had been obtained), the proportion of weight of powder to projectile will be found to be as 1 to 4, but in the new 6-inch gun it nearly approaches 1 to 2.

The advantages obtained by the new system are obvious. In spite of the large charge of powder used, there is a saving of one-half in performing the same work, whilst the weight of the gun is reduced two-thirds. In consequence of the success obtained with this gun, it is understood that guns calculated on similar principles, as worked out by the Experimental Branch at the Royal Arsenal, will shortly be constructed. It is anticipated that one of these new guns, with a bore of 10-inch diameter, and of say 15 tons weight, will be able to take the place of the 12·5-inch, or 38-ton gun, as an armour-piercing weapon in our forts.

The Woolwich guns will be muzzle-loading, but in view of possible conversion to breech-loading at a later stage the steel tubes will be prolonged to the rear of the guns.

When it is considered that a 10-inch gun on the new system will be 3 feet 6 inches longer than the service 12·5-inch, or 38-ton gun, which already projects 16·7 inches beyond the port when run up, it will be seen that the question of breech-loading here instead of muzzle-loading enters a new and very important stage. The extreme difficulty, if not impossibility of loading the new gun at the muzzle, would preclude its being utilized in our casemates without crippling its efficiency by shortening the bore.

In the old form of construction the length of the bore never exceeded 18 calibres, whilst in the new system it ranges from 23 to 26.

Another instance of the advantages derived by an adaptation of the principles, may be found in the new jointed 7-pr. steel gun for mountain service, by the same firm. (Two complete batteries of these guns have been ordered, and are to be sent out to Afghanistan forthwith).

These guns are made in three pieces—viz., breech end, muzzle end, and trunnion ring; and the joint is made in about half a minute by fitting the muzzle end on to the breech end in a vertical position, and clamping them by screwing the trunnion ring over the joint. The exact prolongation of the rifled grooves is effected by the use of what is technically termed a feather, or projection of metal fitting into a corresponding slot. By this ingenious arrangement a gun of much greater capabilities is obtained without increasing the weight of any particular load. The total weight of the gun is now 400 lbs., instead of 200 lbs. Its length is increased from 3 feet 3 inches to 5 feet 6 inches, and it now fires a charge of $1\frac{1}{2}$ lbs. as against 12 oz., and is considered a good gun up to 3000 yards, whilst the 200-lb. gun is stated in Lieut.-Col. Maitland's Lecture, to be only "tolerably" effective up to 2500 yards. One small matter of detail may be noticed in this gun—viz., the reproduction of the muzzle moulding, so well known in the old days of smooth-bore guns. This is added not on account of any pressure exerted from the inside of the bore, but simply because in guns of small calibre the tapering of the metal to the increased length leaves the ring at the muzzle so thin that it might be injured by an accidental fall or blow. The lengthened 12-pr. gun is similarly provided.

M. L.

*Shoeburyness, 1st January, 1879.*

# PAPER IV.

## THE ACOUSTICAL UNIT

OF

# DIMENSIONS OF ROOMS.

By Lieut. F. J. Day, R.E.

Many physicists have written upon the science of acoustics, but few, if any, have considered the subject with a view to practically assisting the architect in the proportioning of halls and rooms, so as to make their contained air vibrate to any musical note that may be communicated to it.

The following paper is therefore submitted to the Corps in the hope of promoting a discussion on the important question of determining the proper unit of dimensions of rooms, in order to make their contained air vibrate to any note that may be communicated to it; thereby engendering those properties in the room which are technically summed up in "the room being good for sound,"—and, if possible, discovering a few simple rules for the guidance of architects in selecting a suitable unit of dimensions for their projected structures, whereby they may ensure the acoustical success of their designs.

The sounds imparted to the air of a building would be those of the human voice or of some musical instrument, of which we may take the organ as a type, for this instrument contains stops which represent the sound produced by every description of instrument, the sounds generated only differing from each other in colour.

This brings us to the consideration of the component parts of the musical note produced by any instrument. viz:—

The pitch, intensity, and colour. The pitch of the musical note is regulated by the number of vibrations of the sound wave per second, the greater the number of vibrations the higher the pitch, and as sound travels with a uniform velocity the greater the number of vibrations the shorter the length of the waves, therefore the shorter the length of the waves the higher the pitch of the note.

The intensity of the sound depends upon the amplitude of vibration, or in other words, on the amount of disturbance generated, but has nothing to do with the length of the waves producing the individual note, nor with the nature of the disturbance.

The colour or *timbre* of the note depends upon the generating instrument; the notes are produced in different ways, and though the pitch be the same, they differ in quality or character according to the nature of the producing instrument. Thus if a particular note is sounded first on the piano, then on the organ, and successively on the flute and violin, or by the human voice, a great difference will be noticed in the sounds produced; this difference is due to many causes; for instance, in the piano the note is struck and the vibration produced, but the intensity rapidly decreases; in the organ the note is continued as long as the air is blown into the pipe; in the flute there is a rushing sound of the wind being blown into the instrument. But the chief reason for the difference is the production of overtones or harmonics of the fundamental note in different intensities by the various instruments; these harmonics not only differ for the various sounding bodies, but even for the same body when sounded in different ways.

We shall see hereafter that any body that will resound to the fundamental note will also resound to its harmonics, so that whatever arrangements are made for the air spaces to resound to the fundamental notes will also hold good for its harmonics. Although the production of the various sounds does not come within the province of the architect, yet he should understand their formation in order to arrange for their reception, and to be able to proportion the various air spaces so as to take up any note communicated to them. It will be well, therefore, to enquire cursorily into the method by which the various notes are produced.

As the stop on an organ representing any instrument differs from the instrument itself, only in the proportion of the harmonics generated in each case, it will simplify our investigation to take the organ as a general representative of musical instruments, and we shall show that if our air space is proportioned to any fundamental note it will also take up any harmonics of that note which may be communicated to it. We have, therefore, only to enquire into the production of sounds by the organ and the human voice.

As regards the organ we need not trouble ourselves with the complicated mechanism by which the various results are attained: suffice it to say that the instrument consists of a case containing many series of pipes, into any of which the wind is admitted by the double action of the stops and keys. The opening of the stops enables the wind to pass into the particular channels with which the several pipes communicate, the openings of these channels being stopped by valves or pallets, which pallets are worked by the keys. On the key being depressed the pallet is opened, and a jet of wind is driven into the foot of the pipe, which sets the lip or reed into vibration, and thus generates the note required.

All organ pipes are constructed either of metal or of wood, and are distinguished by the names of flue and reed pipes. The flue pipe, when made of metal, consists of a body and a foot: the body is generally a cylinder having a small portion towards its lower end slightly flattened inwardly, so as to produce a straight edge; the part thus pressed down does not extend to the bottom of the body of the pipe, but a small portion at its lower extremity is cut off, the edge thus formed being called the upper lip. The foot of the pipe is of conical form, and has a straight edge formed similarly to the one on the body of the pipe, and which is termed the under lip. The top of the foot is closed at its lower broad end by a circular metal plate called a "langward;" a segment of this is cut away so as to produce a straight edge parallel to the under lip, leaving a narrow fissure or flue between them directly underneath the straight edge of the upper lip. The body and foot are soldered together with the lips exactly opposite each other, and the aperture thus formed constitutes the mouth of the pipe.

Wooden flue pipes are of rectangular section, and are constructed on the same principal as metal pipes; they have upper and under lips, a langward, and a narrow fissure to discharge the jet of wind which is admitted into the foot of the pipe and which strikes against the upper lip.

Flue pipes are made to speak by sending a jet of wind into the foot of the pipe; it rushes through the narrow fissure above described, and, by striking against the upper lip of the pipe, sets it in vibration. These vibrations are communicated to the air in the pipe, which is thus set in motion, and sounds the note which the pipe is constructed to produce; the length of the pipe must, of course, be proportioned according to the rate of vibration of the upper lip, which is regulated by the pitch of the note it is intended to sound.

Reed pipes are generally made of metal, the body of the pipe being either cylindrical or conical in form; a cylindrical block of metal with a flange round the upper end to prevent its sinking too deeply into the foot of the pipe, is fixed at its mouth; the reed is a small tube of which a portion is cut away lengthwise; it passes through the centre of the block and is attached to it—the tongue is a thin piece of metal slightly bent, and attached to the reed in such a way as nearly to close up that portion of the reed which has been cut away; a tuning wire passes through the block, the lower portion of which is bent so as to press against the tongue, while its upper part is a little crooked, and is filed in a notch so as to receive the tuning knife; by this means it can either be raised or depressed, and the vibrating portion of the tongue thus lengthened or shortened to sharpen or flatten the pitch of the pipe.

The peculiar tone of the reed pipes arises from the fact of the wind, rushing through the opening between the tongue and the reed, causing the tongue to vibrate; the quicker the vibrations the more acute will be the pitch of the pipe; the length of the pipe is, of course, proportional to the pitch of the note produced by the reed.

From the above we find that all the notes of the organ are produced by setting either the lips or reeds of the pipes in vibration; these vibrating surfaces communicate their movement to the air in the pipes, which, being properly proportioned to the pitch of the note, resound to it, and the pipe is made to speak. From this we may gather that the pipe has nothing to do with the formation of the sound, but only, owing to its length being proportional to the time of vibration of the generating medium, its contained air resounds to the note given out, which thus reinforced becomes audible.

We have next to consider the more difficult subject of the production of sounds and words by the human voice, and in order to do this we must discuss at some length the method of generation of musical notes, vowel and consonant sounds by the human voice.

We proceed first to examine the organs of the human frame which generate and articulate sound, and find at the top of the windpipe an apparatus which leaves for the passage of air only a long narrow slit in the back and front direction, which is called the "glottis." The sides of this slit are not solid masses of animal matter, but elastic bands or ligaments, which, though not very deep vertically, have the power of vibrating to the right and left. The ends of these ligaments are held in position and in a state of tension by different muscles (these, however, have nothing to do with this investigation, which only deals with the actual generation of sound). These elastic bands are called the vocal ligaments, and we must next consider their condition under various circumstances.

When the voice is in a state of rest the vocal ligaments are not stretched with any particular force, and the ends of the right and left ligaments are not pressed together, but, on the contrary, kept apart by certain muscles exerted only with this object. Under these conditions the aperture is sufficiently wide to allow the breath to pass freely, and the ligaments not being stretched there is no cause for setting them in vibration.

But when a sound is to be produced, other muscles come at once into play, the ends of the two ligaments are pressed together, although not probably closely, and, at the same time, the ligaments themselves are extended by other muscles to any required degree of tension.

If then air be forced from the lungs through the "glottis," it rushes with great rapidity through the small aperture, and impinges upon the sides of the ligaments, which are in a state of tension and ready to be set in vibration, thus producing a musical note. The pitch of the note generated, of course, depends upon the degree of tension of the ligaments.

We thus see that to utter a musical sound two sets of muscles are put into action; first, in order to utter a musical sound the right and left ligaments are pressed together, and second, in order to produce a note of a particular pitch the ligaments are stretched to a particular tension, their vibrations being made of longer or shorter duration according as a note of high or low pitch is required. This action is imitated by the organ builder in every reed pipe he constructs; the closing of the ligaments is imitated by introducing the tongue into the portion of the reed which has been cut away, and thereby nearly closing the aperture, and the state of tension is produced by raising and lowering the crooked wire, which presses against the tongue, and thereby lengthens or shortens the vibrating surface and flattens or sharpens the pitch of the note.

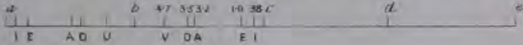
The cavity of the mouth performs to the vocal ligaments the same functions as the body of the organ pipe does to the reed, the air in the resonant cavity of the mouth reinforcing the sounds produced by the vocal ligaments, in the same way as the organ pipe reinforces the note produced by the reed.

Thus far we have traced a likeness between the method of generation of the note produced by the human voice and those of a reed pipe of an organ; but we must now inquire into the method of producing vowel sounds by the human voice, and for this purpose may adduce an experiment made by Professor Willis, and recorded in Volume III. of the *Cambridge Transactions*.

In the experiment he uses a simple pipe, which admits of its length being varied at pleasure. Air is blown through a long channel which terminates in a reed that gives a note of known pitch, and the length of whose air wave is therefore also known; the carrier of this reed is fitted accurately, but not tightly into the pipe, whose length can thus be made variable; the tube is now slid along so as to vary the position of the reed carrier, which thus becomes a plug in the pipe, by varying the position of which different lengths of pipe are left between it and the external air. Professor Willis then points out the following facts :—

"First, that in order to perceive clearly a vowel sound, it is necessary to sound different vowels in succession, the principal effect being produced by contrast, and no distinct vowel sound being impressed on the ear when the apparatus is maintained steadily in the arrangement proper for producing any one vowel.

"Second, the fundamental result of the experiment is this—




"In the above figure let $a$ denote the place where the waves of air enter immediately from the reed (the reed being supposed to be at the left hand and the current of air being blown from left to right), and suppose the tube of variable length to extend from left to right, its mouth sometimes stopping at I, sometimes being advanced to E, A, O, &c. Also let $ac = bd = ce$ length of the sound wave produced by the reed. Then, when the mouth of the pipe is at the point I, it utters the vowel sound "I" (in continental pronunciation) the same vowel sound as in the word "see." When the mouth of the pipe is at E the vowel sound is that of "E" sliding between the vowel sounds in "pet" and "pay." When the mouth of the pipe is at A, O, U the sounds are respectively those of "paa" and "part," followed by "pair," "nought" in "no" and "but" followed by "boot." As the mouth of the pipe is carried towards $b$ (the point bisecting $ac$) sounds become indistinct, and vowel sound is lost; or the only sound perceptible is that of our short U. On approaching $c$, the same vowels re-occur, but in opposite order On proceeding further still, the same phenomena recur after an addition to the "pipe length" of the "length of the air wave," double the "length of the air wave," &c., but all sounds become less forcible.

"Now, upon varying the pitch of the reed (that is upon varying the length of the sound wave or the length of the spaces *ab*, *bc*, *cd*, *de*) the lengths *a* I, *a* E, *a* A, *a* O, *a* U, *e* E, &c., remain unaltered. And when a reed of high pitch is used, or when the spaces *ab*, *bc*, &c., are made very short, some of the vowels U, O, &c., are lost. This accords with the experience of singers of high pitch, who can sing no vowel but I (sounded as in "see"). The distances of the vowel positions from *c* or from *e* are as follows; the distance when measured from *a* is rather less than in the other cases:—

$$
\begin{array}{lll}
\text{“}c\,\mathrm{I} = e\,\mathrm{I} = & 0{\cdot}38 & \text{inches.} \\
c\,\mathrm{E} = e\,\mathrm{E} = & \begin{cases} 0{\cdot}6 & \text{,,} \\ 1{\cdot}0 & \text{,,} \end{cases} & \\
c\,\mathrm{A} = e\,\mathrm{A} = & \begin{cases} 1{\cdot}8 & \text{,,} \\ 3{\cdot}2 & \text{,,} \end{cases} & \\
c\,\mathrm{A}' = e\,\mathrm{A}' = & \begin{cases} 3{\cdot}05 & \text{,,} \\ 3{\cdot}08 & \text{,,} \end{cases} & \\
c\,\mathrm{O} = e\,\mathrm{O} = & 4{\cdot}7 & \text{,,} \\
c\,\mathrm{U} = e\,\mathrm{U} = & \text{indefinite.”} &
\end{array}
$$

From these phenomena Professor Willis draws the following deductions:—

That from the air of invariable pressure at the mouth of the pipe there is a kind of reflection of the sound wave inwards, and thus every reed wave travelling along a pipe is reflected from the open mouth at a time depending upon the length of the pipe, the relation of which time to the time of the next reed wave will be different for different lengths of the pipe, thus producing a mixed wave whose quality varies with the changes of that relation. This amounts to nearly the same as saying that each puff of air through the reed may create a wave which travels with organ wave velocity coexisting with the one which follows the laws of resonance.

The following experiment pointedly illustrates this law. If a quill be snapped by the teeth of a wheel in rapid rotation a musical note is produced; but if, instead of a quill, a highly elastic spring is used, itself competent to give a musical tone, then a vowel sound is produced, and the name of the vowel depends upon the relation between these two musical notes, which relation is altered by grasping the spring at different points.

From this we infer that the actual vowel sounds are produced by a secondary wave which is coexistent but independent of the pitch wave, although it conforms closely to it; and, therefore, if we proportion our building to resound to the pitch wave, it will also accommodate itself to the secondary wave which produces the vowel sound.

We have now only to enquire into the production of consonant sounds, about which there is little to remark. They depend on the mode of beginning or ending an utterance of a vowel sound. Sometimes this is done at the glottis, sometimes at the beginning of the utterance by lowering the tongue from the palate, sometimes by opening the lips, sometimes by opening the teeth. In some cases a vowel sound must be formed before opening the lips, thus a momentary dull vowel sound within the mouth before opening the lips appears necessary to give the sound "bee"; if there be no such antecedent dull vowel sound, the sound emitted will be "pee." In closing the utterance of the vowel sounds, there is nearly the same variety. All these different modifications give rise to different consonants, but they do not appear to involve any particular principle which requires our attention. The rolling sound of the "r," the hissing sound of "s," and the guttural sounds of "och" and "ach," which seem to be produced rather in the palate than in the throat, also the sounds of "sh" and "th," appear to be abandonments of musical utterances, and probably do not require any action of the vocal ligaments, their peculiarities being given by the tongue, teeth, cheecks, and lips.

We find, therefore, that the variations of sound produced by the consonants are caused by cutting off either the beginning or ending of the vowel sound in all cases before it leaves the lips of the speaker, and, therefore, for our purpose we may say, before it has left the source of generation. Further, we have found that a column of air will resound to a note, giving a vowel sound, and it needs no demonstration to show that it will resound to any portion of this sound, or, in other words, to any variation produced by the addition of consonants. And in whatever way this vowel sound has been modified in its production, it will be similarly modified in its reproduction, for there is no external cause which by acting upon it could make any alteration. We conclude that if air contained in a building will resound to the pitch wave of a note it will also resound to the wave when modified, either by a vowel or consonant sound, or their combination into words.

For the purpose of architectural construction we have, therefore, reduced all sound waves, produced by either the human voice or musical instruments, to the dimensions of those of the pipes of the organ of known lengths, and are now in a position to discuss the most suitable unit of dimension for rooms.

The first point to be considered is whether the laws which govern the undulations of columns of air in organ pipes will hold good for columns of air in rooms?

This question cannot be better answered than by Professor Airy's description of a Plane Wave of three dimensions (*Airy's Sound and Atmospheric Vibrations*, p. 38).

"If we have a great number of pipes side by side with waves of a similar character passing simultaneously through all, so that the collateral condensations and pressures of air in the adjacent pipes will be the same, there will be no tendency of the air in one pipe to press sideways into another pipe; we may therefore remove the material boundaries of these pipes, and then we have air, extended in three dimensions through which passes a wave, whose front is a plane, that is, in which all the points of similar motion and similar density are always in one plane."

Suppose, therefore, our room to be filled with organ pipes all radiating from the mouth of the speaker, the same wave passes through each pipe, and the result will not be affected if we remove the material boundaries of the pipes; let these be removed and we have a sphere of sound obeying the same laws as the column of air contained in the organ pipes

The architect, of course, has nothing to do with the generation of sounds, but has only so to proportion his building that its contained air will take up and intensify any sound that is communicated to it. The method of generating the various sounds produced on the organ to represent the human voice and musical instruments is too long to give in this paper, and we therefore take it for granted that different lengths of pipe will resound to any note of any instrument that may be communicated to them, and for the details of their construction must refer the reader to Chapter XXIII. of Hopkins' *History of the Organ*.

The problem before us is to make the contained air space of a building take up any musical note that may be communicated to it. We propose to solve the problem by finding, first, a length which will resound to all the eight notes of the musical octave, and then to combine this length with those of the note "C" on the human voice and the various stops of a large organ.

In Ganot's *Physics* (Art. 207, p. 163, Ed. 1866) we have: "Hence if $m$ denotes the number of double vibrations corresponding to the note C, the number of vibrations corresponding to the remaining notes will be given by the following table:—

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| "C | D | E | F | G | A | B | c |
| $m$ | $\frac{9}{8}m$ | $\frac{5}{4}m$ | $\frac{4}{3}m$ | $\frac{3}{2}m$ | $\frac{5}{3}m$ | $\frac{15}{8}m$ | $2m$" |

To produce which alteration in the number of vibrations the difference in the length of the pipes or waves must be:

$$D=\tfrac{8}{9}C,\ E=\tfrac{4}{5}C,\ F=\tfrac{3}{4}C,\ G=\tfrac{2}{3}C,\ A=\tfrac{3}{5}C,\ B=\tfrac{8}{15}C,\ c=\tfrac{1}{2}C,$$

we have therefore to find a length which will be a multiple of all these lengths, or, in other words, to find the least common multiple of the fractions

$$\tfrac{8}{9},\ \tfrac{4}{5},\ \tfrac{3}{4},\ \tfrac{2}{3},\ \tfrac{3}{5},\ \tfrac{8}{15},\ \tfrac{1}{2},$$

or reducing to the least common denominator of

$$\frac{160,\ 144,\ 135,\ 120,\ 108,\ 96,\ 90}{180}$$

This we find to be $\frac{4320}{180}$ or 24.

The number 24 is a multiple of all the fractions representing the difference in length of the waves between that sounding C and its octave, and if the length-sounding C be denoted by $l$, $24l$ will be the least length which will be a multiple of the lengths of the waves sounding the octave.

We next have to combine this with the various stops of a large organ; to do this let us take the specification of an organ with 87 stops given in Hopkins' *History of the Organ*, page 326:—

GREAT ORGAN, 22 STOPS.

| | | | | | |
|---|---|---|---|---|---|
| 1. Sub Bourdon to tenor c key. | 32 | ft. tone. | 12. Flute. | 4 | ft. tone. |
| 2. Double open Diapason. | 16 | ,, | 13. Twelfth. | $2\frac{2}{3}$ | ,, |
| 3. Bourdon. | 16 | ,, | 14. Fifteenth. | 2 | ,, |
| 4. Open Diapason. | 8 | ,, | 15. Piccolo. | 2 | ,, |
| 5. Open Diapason. | 8 | ,, | 16. Full Mixture, III. Ranks. | 2 | ,, |
| 6. Gamba. | 8 | ,, | 17. Sharp Mixture, V. Ranks. | 2 | ,, |
| 7. Stopped Diapason | 8 | ,, | 18. Cornet, II., III., and IV. Ranks. | | ,, |
| 8. Clarabella to tenor c. | 8 | ,, | 19. Double Trumpet | 16 | ,, |
| 9. Quint. | $5\frac{1}{3}$ | ,, | 20. Posaune. | 8 | ,, |
| 10. Principal. | 4 | ,, | 21. Trumpet. | 8 | ,, |
| 11. Principal. | 4 | ,, | 22. Clarion. | 4 | ,, |

SWELL ORGAN, 20 STOPS.

| | | | | | |
|---|---|---|---|---|---|
| 23. Bourdon. | 16 | ft. tone. | 28. Voix Celeste. | 8 | ft tone. |
| 24. Open Diapason. | 8 | ,, | 29. Principal. | 4 | ,, |
| 25. Gamba. | 8 | ,, | 30. Gambette. | 4 | ,, |
| 26. Echo Dulciana. | 8 | ,, | 31. Flute. | 4 | ,, |
| 27. Rohr Gedact. | 8 | ,, | 32. Twelfth. | $2\frac{2}{3}$ | ,, |

Swell Organ, 20 Stops.—(*Continued.*)

| | | |
|---|---|---|
| 33. Fifteenth. | 2 ft. tone. | |
| 34. Octave Flute. | 2 | ,, |
| 35. Mixture, V. Ranks. | 2 | ,, |
| 36. Echo Dulciana, Cornet V. Ranks | 4 | ,, |
| 37. Double Bassoon | 16 ft. tone. | |
| 38. Hautboy. | 8 | ,, |
| 39. Trumpet. | 8 | ,, |
| 40. Horn. | 8 | ,, |
| 41. Clarion. | 4 | ,, |
| 42. Vox Humana. | 8 | ,, |

Choir Organ, 15 Stops.

| | | |
|---|---|---|
| 43. Lieblich Bourdon | 16 ft. tone. | |
| 44. Open Diapason. | 8 | ,, |
| 45. Lieblich Gedact | 8 | ,, |
| 46. Flauto Traverso. | 8 | ,, |
| 47. Dulciana. | 8 | ,, |
| 48. Keraulophon. | 8 | ,, |
| 49. Spitzflöte. | 4 | ,, |
| 50. Dulcet. | 4 | ,, |
| 51. Flute. | 4 | ,, |
| 52. Twelfth. | $2\frac{2}{3}$ ft. tone. | |
| 53. Gemshorn. | 2 | ,, |
| 54. Flageolet. | 2 | ,, |
| 55. Mixture, IV. Ranks. | $1\frac{1}{3}$ | ,, |
| 56. Corno di Bassetto. | 8 | ,, |
| 57. Bassoon throughout. | 8 | ,, |

Solo Organ, 12 Stops.

| | | |
|---|---|---|
| 58. Bourdon. | 16 ft. tone. | |
| 59. Violin Diapason. | 8 | ,, |
| 60. Flute Harmonic. | 8 | ,, |
| 61. Violino. | 4 | ,, |
| 62. Flute Octaviant. | 4 | ,, |
| 63. Piccolo Harmonic. | 2 | ,, |
| 64. Contra Fagotto. | 16 ft. tone. | |
| 65. Clarinet. | 8 | ,, |
| 66. Hautboy. | 8 | ,, |
| 67. Hautboy Clarion. | 4 | ,, |
| 68. Tuba. | 8 | ,, |
| 69. Tuba Clarion. | 4 | ,, |

Pedal Organ, 18 Stops.

| | | |
|---|---|---|
| 70. Double Open Bass, wood. | 32 ft. tone. | |
| 71. Double Open Bass. | 32 | ,, |
| 72. Open Bass, wood. | 16 | ,, |
| 73. Great Bass, wood. | 16 ft. tone. | |
| 74. Violone. | 16 | ,, |
| 75. Stopped Bass. | 16 | ,, |
| 76. Great Quint Bass. | $10\frac{2}{3}$ | ,, |
| 77. Principal Bass, Metal. | 8 ft. tone. | |
| 78. Violoncello, wood | 8 | ,, |
| 79. Flute Bass. | 8 | ,, |
| 80. Twelfth Bass. | $5\frac{1}{3}$ | ,, |
| 81. Fifteenth Bass. | 4 | ,, |
| 82. Mixture, IV. Ranks. | $3\frac{1}{5}$ ft. tone. | |
| 83. Contra Posaune | 32 | ,, |
| 84. Posaune. | 16 | ,, |
| 85. Bassoon. | 16 | ,, |
| 86. Trumpet. | 8 | ,, |
| 87. Clarion. | 4 | ,, |

From inspection it will be seen that the least common multiple of the lengths of all these pipes or waves sounding C is 32 feet, and that of the Vox Humana stop is 8 feet; if, therefore, we give these values to $l$ and combine them with the least common multiple of the musical octave, we shall obtain the lengths required, which will be as follows:—

For any stop on the organ, *i.e.*, any instrument. $32 \times 24 = 768$ feet.
For the human voice ... ... ... ... ... ... $8 \times 24 = 192$ feet.

These lengths are multiples of the lengths of any wave that may be sounded, but it may be doubted whether the lengthened column of air will resound to any particular note, the length of whose wave is only a fractional portion of the whole.

The following extract from Weale's *Acoustics*, page 10, seems, however, to set this point at rest.

"If the agitation in the pipe be made more intense, a point will be reached in which the air will divide itself into two equal lengths —and in each half of the pipe vibrations will go on precisely as would occur in a pipe of half the length. As these pulses have only half as far to go, but travel at the same unalterable speed, two of them will be heard where one was before. The next note that can be produced by more vigorous agitation is that following the division of the pipe into three lengths." This is corroborated by Hopkins in his *History of the Organ*, page 212, para. 885, where he states that a pipe will occasionally sound its octave when it is too much winded, and from other causes, and we even find that pipes are occasionally made to sound their harmonics purposely, as in the case of the Harmonic Flute (Hopkins, page 137) which is a flute stop of 8 feet pitch, but of which the pipes are of double length, either blown by a heavy wind or simply copiously winded.

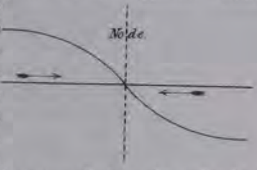
We may, therefore, infer that a given pipe will sound several notes provided they are fractional parts of the whole length, and our unit of length being a multiple of all the waves that can be communicated to it either by the organ, or by the human voice, it will take up any note sounded in the building.

These lengths, as they stand, are, however, practically useless, as the limits to which a speaker can be heard are about 92 feet to his front and 31 to his rear. The length must therefore be broken up in some way, and that this breaking or doubling is practicable, may be inferred from Ganot's *Physics*, page 175, Ed. 1866, which runs as follows:—"It must be added that if a closed and an open pipe yield the same primary tone, the closed pipe must be half the length of the open pipe." The same fact is given in different words in Hopkins' *History of the Organ*, page 110, para. 434, and moreover we find that brass instruments which, when extended, would be of unmanageable length, are coiled up into a number of turns to make them portable. This shows that the sound wave may be doubled up without being affected, and we are, therefore, led to suppose that any division will answer our purpose, but were we to act upon this conclusion the result would probably be that our room would reproduce every note communicated to it in the form of a noise and not in that of a musical note, and as this is a point which should be carefully guarded against, we describe the difference between a sound producing a musical note and a noise. The following is taken from the *Encyclopædia Brittanica*, vol. i., page 107, Art. 104:—

"Besides the three qualities above mentioned (amplitude, timbre, and pitch) there exists another point in which sounds can be distinguished from each other, and which, though perhaps reducible to difference of timbre, requires some special remark, viz., that by which sounds are characterised either as *noises*, or as *musical notes* A musical note is the result of regular periodic vibrations of the air particles acting on the ear, and therefore also of the body whence they proceed, each particle passing through the same phase at stated intervals of time. On the other hand, the motion to which noise is due is irregular and flitting, alternately fast and slow, and creating in the mind a bewildering and confusing effect of a more or less unpleasant character."

The object we wish to attain, therefore, is to divide the sound wave in such a manner that it may always be reflected evenly and regularly from the surfaces with which it comes in contact. For this purpose we must examine the way in which the air vibrates in pipes, and draw our conclusions by considering the air in the room to vibrate similarly to the air in a pipe closed at both ends. This cannot be better described than by Bernouilli's Theory, of which the following is a summary:—

"In dealing with the theory of pipes we must treat the air precisely in the same manner as we have dealt with elastic rods vibrating lengthwise, a pipe stopped at both ends being equivalent to a rod fixed at both ends, a pipe open at both ends to a rod free at both ends, and a pipe stopped at one end and open at the other to a rod fixed at one end and free at the other. When, therefore, air within a pipe is everywhere displaced along the length of the pipe, two waves travel thence in opposite directions, and being reflected at the extremities of the pipe, there results a stationary wave with one or more fixed nodal sections, on one side of which the air is, at any moment, being displaced in one direction, while on the other side it is being displaced in the opposite. Hence when the air on both sides of the node is moving towards it, there is condensation going on at the node, followed by rarefaction on the reversal of the motion of the air. As a stopped end prevents any motion of the air, a nodal section is always found there, and as




at the open end, we may conceive the internal air to be maintained at the same density as the external air, we may assume that such end coincides with the middle of a ventical segment."

From these assumptions, which form the basis of Bernouilli's theory of pipes, we infer—

That in a pipe stopped at both ends, as in a rod fixed at both ends, there must be a note at both ends, and that any overtones compatible with this arrangement may be produced. From this it is evident that any harmonic division would answer our purpose.

These harmonic divisions are $\frac{1}{1}$ $\frac{1}{2}$ $\frac{1}{3}$ $\frac{1}{4}$ &c., but no fraction which has not unity for its numerator will do.

Here, however, we may fall into another error and give the sounds when reproduced by the building a nasal tone, unless we exclude the uneven divisions from our list; for if the predominant units of the building were one of the uneven harmonic divisions, the result on the reproduction of the sound might be the same as that of a narrow stopped organ pipe which gives out a poor and even nasal sound, as may be gathered from the following extract from the *Encyclopædia, Britannica* (vol. i., page 108): "The same character of softness belongs also to these instruments in which the powerful harmonics are limited to the vibrations 2, 3, . . . 6: because the mutual interference of the fundamentals and their harmonics gives rise to concords only. The piano, the open organ pipe, the violin, and the softer tones of the human voice, are of this class. But if the odd harmonics alone are present, as in a narrow stopped organ pipe, and in the clarionet, then the sound is poor and even nasal; and if the higher harmonics beyond the 6th and 7th are very marked, then the result is very harsh (as in reed pipes)."

From this we infer that there is danger in admitting the odd harmonic divisions into our calculations, as by their introduction the ruling note might become one of the odd harmonics, and the sounds communicated to the air of the building be thereby distorted in reproduction. We therefore propose only to use the even divisions such as the $\frac{1}{2}$ $\frac{1}{4}$ $\frac{1}{8}$ $\frac{1}{16}$ $\frac{1}{32}$ $\frac{1}{64}$, &c. This will reduce the figures previously found as follows:—

| | For the Organ or any Instrument. | For the human Voice. |
|---|---|---|
| Unity. | 768 feet. | 192 feet. |
| $\frac{1}{2}$ | 384 ,, | 96 ,, |
| $\frac{1}{4}$ | 192 ,, | 48 ,, |
| $\frac{1}{8}$ | 96 ,, | 24 ,, |
| $\frac{1}{16}$ | 48 ,, | 12 ,, |
| $\frac{1}{32}$ | 24 ,, | 6 ,, |
| $\frac{1}{64}$ | 12 ,, | 3 ,, |
| $\frac{1}{128}$ | 6 ,, | $1\frac{1}{2}$ ,, |
| $\frac{1}{256}$ | 3 ,, | 9 inches. |
| $\frac{1}{512}$ | $1\frac{1}{2}$ ,, | $4\frac{1}{2}$ ,, |
| &c. | &c. | &c. |

Thus bringing the lengths first found down to practical dimensions.

Having found our units we proceed to design our building; the object in view is to make the contained column of air a harmonic of any undulation that can be communicated to it. But the whole of the lengths found above are harmonics of any of the notes produced either by the human voice or a musical instrument, and it needs no demonstration to shew that their multiples will either be harmonics or multiples of the same notes, therefore any lengths we take that are multiples of those above found will answer our purpose.

Having first determined the position of the speaker or the orchestra, and adopted a convenient unit, the height is made a certain multiple of this unit, the breadth a certain multiple, and the length before and behind the speaker a certain multiple, the best results being probably produced by giving these multiples some harmonic relation to each other. Here we find the advantage of having excluded the uneven harmonics from our previous calculations, in the fact that we are not forced to make each dimension an even multiple of the others, but may make one or more of them uneven multiples without danger of generating a predominance of the uneven harmonics, and thereby impoverishing the sounding properties of the columns of air contained in the buildings.

In conclusion we give the dimensions of a few well known rooms viz.: the Free Trade Hall at Manchester has a height of 58 feet, a breadth of 78 feet, and a length of 123 feet to the front of the orchestra, and 135 feet to the back, which gives a unit of 3 feet, the height being 19 units, the breadth 26 units, and the length 41 or 45 units, being a relation between height and breadth of nearly two to three, and between height and length of nearly two to five. The Theatre of the Royal Institution has a length of $44\frac{1}{2}$ feet, a breadth of $59\frac{1}{2}$ feet, and a height of 29 feet, which practically gives a unit of three feet, the length being 15 units, the height 10 units, and the breadth 20 units, giving a relation between length and height of three to two and between height and breadth of one to two. The new room constructed by Professor Donaldson, at Edinburgh, has a height of 48 feet, a width of 36 feet, and a length of 90 feet, giving a unit of six feet, the height being eight units, the breadth six units, and the length 15 units. The relation between breadth and height being three to four, and between breadth and length three to $7\frac{1}{2}$.

Here we have three rooms known as acoustical successes, all of which embody the rules enumerated in the foregoing pages, and would therefore seem to point to the correctness of the theories set forth. The subject however is one that has seldom been considered, and errors may have crept in which can only be eradicated by free discussion. This paper is therefore submitted to the Corps for the purpose of eliciting comments from officers who have studied the subject, and with the hope of—in the end—obtaining definite rules for the guidance of architects in proportioning the internal dimensions of their structural designs, so as to ensure acoustical success.

F. J. D.

# PAPER V.

# SHELTER TRENCHES

## AND

# FIELD FORTIFICATION.

(*From the Rivista Militare Italiana.*)

BY MAJOR TRINCHIERI, OF THE ITALIAN ENGINEERS.

ABSTRACT BY LIEUT.-COLONEL E. R. JAMES, R.E.

## I. SHELTER TRENCHES.

REFERRING to the systematic, but not always justifiable, employment of field fortification in the war of secession, Lecomte described it as amounting sometimes to abuse, and traced this to the military teaching of West Point. In the South it had, he said, become a mania from the facility of execution. The negro slaves did not make good soldiers but were splendid labourers.

The author of this paper thinks that the breaking out of the war in 1861 is worthy of study from many points of view. Washington, Richmond, Petersburg, and other political and commercial centres, were open and undefended, and equally so were the railway junctions. The railways in such a vast country stand in the place of roads; they are frequently crossed by watercourses; and the positions thus indicated bore a remarkable part in the operations. The few regular troops were dispersed, and the combatant armies were formed mainly of newly-embodied militia and volunteers who were unable to fight in the open country, and hence field fortifications became, as it were, a necessity on both sides. For the South the negroes were a ready supply of labourers, and the bulk of the West Point officers being on that side naturally tried to profit by this circumstance. From the system of cultivation there was very little natural cover, and it was necessary to protect the troops against the extraordinary newly-developed power of the breech-loading arms. The skill in the construction of field-works became, from these causes, so great, that they were used to even too great an extent, and were often thrown up actually under fire.

The first mention of rapidly-constructed entrenchments being thus thrown up was on the second day of the battle of Chancellorsville, on the 3rd May, 1863; after which the employment of this kind of cover became frequent, both offensively and defensively, until the last fights in March, 1865, round Petersburg, where it is stated that, in a slowly-effected change of front by a division, two lines of flying trenches were almost completed and, in turn, abandoned within an hour.

Since the American War the question of shelter trenches has been considered in every army. Experiments on their construction were made at the Chalons Camp in France, and at the Camp of Foiano in Italy, of which the results are summed up by Brialmont in his work on improvised fortifications, published in 1872. There is now a general agreement as to the most convenient profile, and as to the disposition of the workmen; but the conditions under which shelter trenches can be most usefully employed, and the means, are still disputed points. As to the means there are three distinct opinions, viz. :—

1. Every soldier should carry a tool.
2. Only a portion of the troops should carry tools.
3. Tools should be supplied to the engineer parks, and carried in special wagons.

The first plan has been thoroughly tried in Russia, and, in the opinion of the author, cannot be recommended, because, firstly, average troops cannot bear any increase in their already too heavy equipment; and secondly, one-quarter or, at the most, one-third of a body of troops is sufficient to place the whole under cover in a few minutes. Therefore the carrying of two-thirds of the tools would be a pure loss to the strength and mobility of the troops.

The second system is adopted in the Danish army, in which a tool with a moveable haft is given to each file; in Prussia, where one-quarter of the soldiers carry the Linneman spade; while in Austria, and in Russia, tools are carried in the proportion of one to three men, The third method is that which has been adopted in France and Italy. The few picks and shovels in possession of the infantry pioneers are scarcely sufficient for the ordinary camp work, and the additional tools necessary for shelter trenches and field works ought to be carried, in the proportion of 820 shovels and 400 picks to a *Corps d'Armée*, with a reserve in the engineer parks.

Of the three systems, the author condemns the first and considers the second the most practical. He considers that it would be quite possible to find a section of men per company, in the Italian infantry, each physically capable of bearing the additional weight of one short-handled tool.

Speaking of the moral effect of encouraging the construction of shelter trenches, he does not think soldiers, trained to make use of natural cover, will allow artificial cover to tie them to the ground when it is necessary to move on to the open.

The author, regarding the arable ground in the basin of the Po as peculiarly well adapted to the use of the spade, thinks that the system now adopted in Italy will result in failure, nine times in ten, from the materials not being at hand at the critical moment, notwithstanding that there may be a rule that the tool carts shall be placed near the head of the column. He mentions an instance of such a failure at St. Privat, on the evening before the battle of Gravellote, where the 6th Corps, under Canrobert, with the finest opportunity for strengthening their front and right flank from Roncourt to the Jaumont wood, could do nothing for want of an engineer park.

Under any circumstances the proportion of tools for a *Corps d'Armée*, which in Italy is fixed at the number of 990, exclusive of 336 carried by the infantry pioneers, is, relatively to the number carried in the army reserve, much too small.

The special instructions issued to the Italian infantry pioneers fix the following conditions which shelter trenches should satisfy:—

1st. Resistance to penetration of rifle bullets.

2nd. Cover to the soldier in firing positions.

3rd. No obstacle to offensive movements.

4th. Of easy and quick execution.

The first two conditions are satisfied by giving minima dimensions for the height and thickness of the earth, and the third by excavating the earth both from small internal and external ditches, with a berm for a step, and with intervals between the fronts of the companies or battalions employed to allow troops of other arms to pass counter approaches; to cover gaps in the advanced posts; to shelter selected marksmen thrown forward; to hinder reconnaissances; to search folds of ground beyond the view of the main works; and to obtain a fire on troops posted at a distance. On the field of battle they may be prepared, if there is time, in successive lines of defence. They may be constructed by reserve troops during the progress of a fight (employing the men alternately, in order not to fatigue them too much) partly with the object of furnishing occupation to the men at moments when nothing is worse than inaction, and partly to render them more confident when they are ordered to advance, since they will know that they leave cover which they can take advantage of should they be compelled to yield ground.

In general, however, the extension of the trenches should be limited to a selected part of the battle-field, where they will act as a rallying point; and their too wide development must be considered to indicate a badly selected position.

The general planning of the limits of the trenches rests with the staff, but the actual trace and execution are the duties of the engineers and immediate commanding officers of the troops employed.

Should there be a possibility of an attack during the execution of the trench, the workmen should be covered by a strong line of skirmishers, well supported, because there would be no advantage, but possibly great danger, in holding such troops 50 yards in rear, the position they would otherwise probably be in. This suggestion has been made by all who have treated of shelter trenches, and it is usually practised in Germany and elsewhere in drill and instruction.

At Cold Harbour, on the night of the 4th June, 1864, the Federal troops, covered by a well supported line of advanced posts which were pushed to within 200 paces of the enemy, employed the whole reserve force to entrench the entire front. On this occasion entrenching tools were wanting, and it is related that the troops used sabres, bayonets, and every kind of rough tool to dig with, and by the help of branches of trees and planks, succeeded in forming a line of trench of real value before daybreak.

It is thought that shelter trenches should be occupied by the troops who construct them, because the work will be better, and the soldier having confidence in it, will defend it with greater obstinacy. Brialmont finds, in this consideration, additional reason for requiring that every soldier should carry a tool. But as, by employing men in without having to cross the trench. The fourth condition is satisfied by a proper disposal of the workmen, and by regulating the work so that it may pass gradually from a simple to a solid form of profile, and be capable of defence by men in a lying position in a few minutes, gradually being strengthened until the men are able to stand and the parapet will resist grape and splinters.

With smooth-bore muskets the dangerous zone extended at the most 300 yards, and could be crossed in a few minutes with slight losses under the then slow fire of the defenders, who reserved their fire to the last, and trusted to the obstacles caused by the ditch and parapet, and to the short flanking defences formerly always provided, and thus the possession of a work was often decided by a hand-to-hand fight. At the present day the attackers cannot reach the edge of the ditch under the fire of breech-loaders without a previous heavy loss, and the moral effect of this weakens their final effort and makes it very uncertain of success.

At such a moment modern tactics counsel a resolute counter-attack, and to allow of this a shelter trench must be of simple trace and low relief. The small flanks of old days being no longer an advantage, the trench should only be bent with the accidents of the ground, and the whole front of the attack should be seen from the trench over the ground likely to be traversed by the enemy in advancing.

In constructing shelter trenches, or manœuvre fortifications as they have been called, cultivated and loosened ground must be preferred, when other conditions are satisfied, as being that on which the work will be most rapid and the effect of the enemy's fire the least to be feared. The trenches should, if possible, be behind trees and hedges, as these serve to assist in forming the revetments, as well as to conceal the troops employed. But, above all, it is necessary to take advantage of the natural form of the ground and, by doing this skilfully, the defensive value of the trenches may be doubled. Referring to the instructions to the Italian pioneers quoted, the sites for the trenches should be determined by the critical judgment which is used to mark out the salient points of the front of battle, by which selection is made of the sites of field-works, detached posts, inaccessible heights, woods and villages to be defended, and the directions of the trenches as curtains. Shelter trenches may be used to connect insuperable obstacles—rivers, marshes, &c.—and thus they may be protected against enfilade, and, at the same time, compel a front attack. They are well adapted for turns, all may assist in the construction of a trench, there does not seem much force in this argument. It is, however, right to distinguish between trenches intended to be merely auxiliary to the defence of a position, and those which are intended to offer a stout resistance. The latter assume the character of real field fortifications, and nothing should be neglected to induce the soldier to place confidence in them and defend them obstinately. But the former should not have in the soldier's mind a greater value than the ordinary natural cover he is trained to take advantage of to support his fire, but which he is taught to abandon with indifference at the command to advance or retire.

Taking this into consideration we can understand why, in Germany and Austria, a marked preference has been shown for shelter trenches of the weakest profile, only capable of covering men in the lying position. It is thought that if, as a rule, more substantial trenches are made use of, the fault of tying the soldier to the ground and making him less confident of himself in the open will be fallen into; and it has been said that the inconvenience of this would so far exceed the advantages of shelter trenches that it would be preferable to do without them than to rely too much upon them.

The following are examples of the use of shelter trenches in recent wars:—

At Königratz, by the Austrians, on the 2nd and 3rd July, the trenches on the front and left of the 3rd Corps were usefully served; but those on the right, between Klum and Nedelist, were only utilized temporarily during the retreat of the 2nd and 4th Corps which, contrary to the orders of Benedek, had taken up their positions too far to the front of the trenches on the line Klum, Maslowed, Horenowes.

At Woërth, the trenches and abattis on the left, on the slopes of the Fröschwiller heights, in stopping the repeated attacks of the 1st and 2nd Bavarian Corps, contributed to the fact that on this side the resistance was supported until evening, and until the line of retreat was threatened by the success of attacks on the right and centre.

The same happened at Spicheren, where the trenches on the Rotherberg and in rear of it, combined with the vigorous counter-attacks by Laveaucoupet's division, arrested the Prussian progress until night.

At Columbey-Nouilly, the murderous fire from the French trenches commanding the Columbey brook, between the Saarlouis and

Saarbrucken roads, stopped the attack of the 43rd Regiment and of the riflemen forming the advanced guard of the 1st Prussian Corps, and contributed to prolong the contest for the possession of the heights until seven o'clock in the evening.

A system of shelter trenches strengthened the position of the 2nd and 3rd French Corps at Gravelotte, but these, according to the Prussian official account, were not used to advantage because the counter-attacks were not undertaken with any ulterior aim. But according to the account by General Frossart, commanding the 2nd French Corps, the relatively small losses of the troops covered by the trenches, is pointed out as a remarkable example of their useful employment.

Although the Germans in 1870-71 had less cause than the French to make use of this tactical assistance, and obtained without it such portentous results, they do not hold it of less account, great care being taken in peace time to instruct their infantry in the construction of hasty entrenchments. An Italian officer of experience states that, being present at the last German manœuvres, he noticed that scarcely did the army take up a position than the troops would begin to entrench themselves, and he quotes one occasion when, the advanced guard of a division having to maintain an obstinate resistance on an exposed height, they threw up shelter trenches; the ground was newly ploughed and, as at Cold Harbour in the war of secession, the soldiers supplemented the scanty supply of Linnemann spades by throwing up the earth with their hands to cover themselves more quickly.

In the recent Russo-Turkish war, hasty entrenchments bore an important part. The Turks seemed to employ them instinctively, though, at first, not very skilfully. Latterly, they used them to great advantage; and after the repulse sustained by the Russians before Plevna on the 29th and 30th July, the latter commenced to avail themselves of the same means to a larger degree, and to the fact that they did so the eventual fall of Plevna may be attributed.

## II. Field Works.

Field works are as old as war itself, but being originally employed to strengthen and secure encampments and investments, with the progress of the military art they have become an auxiliary on the battle-field itself, but modified in form and in method of execution. But the improvements in field works have not advanced *pari* *passu* with those in tactics; at one time tactics emancipated themselves from fortifications; at another, fortifications were superior to tactics, yet when both have been judiciously combined it has been with the certain result of obtaining equal effects with smaller means and fewer losses.

During the seventeenth and eighteenth centuries, the distinction between these two important branches of the military art was strongly marked. The rigid and complicated forms, the mutually dependent parts, the absurd rules of symmetry, and the fixed dimensions considered absolute in fortifications were thought more important than the choice of ground or the direction of the fire; the continuous lines employed were often, as facts proved, opposed to tactical convenience; and, in short, the tendency to make troops immoveable, and to force them to a passive defence, caused tactics to suffer a visible slackening in their forward progress.

Napoleon I. saw the faults of this state of things, and, in his campaigns, while he recognized the importance of field fortifications, the art of tactics again assumed its true place.

Since his day, the habitual use of skirmishing order, the use of rifled artillery and breech-loading small arms, have given rise to new tactical conditions, rendering the employment of field fortifications more frequent and necessary; but in order to follow the rapid defensive and offensive changes on fields of battle, it has become requisite to put away the old rigid forms and to adopt others more simple and expeditious, based on the exclusion of the absolutely passive defence, and on the principle that the attacker must be prepared to defend, and the defender to attack.

The modern artillery is capable of high penetration at distances unknown in former times, and the explosions of the new projectiles produce craters which soon weaken the stability of ground when the slopes are not of the flattest kind. At small ranges by reducing the charges, indirect fire with high penetration may be employed, by which objects masked by covering masses may be struck; at long ranges the same result may be obtained by high-angle fire. The range and the penetration of projectiles from rifled breech-loading muskets are also notably increased. The modifications which, consequently, are made in field works are the following:—

An increase in the thickness of parapets intended to resist continued fire is necessary, together with a diminution of the exterior slope of the covering mass, and of the slope of the escarp. There must be an increase to the height and steepness of the counterscarp to compensate for the greater facility given to the assault by the easier slope of the escarp, and to cover the work from indirect fire. There should be a glacis to expose the enemy better as he approaches the counterscarp; its crest should be elevated a quarter of the width of the ditch above the ground level. The ditch must be enlarged to furnish the necessary earth for the increased thickness of parapet, and this will increase the difficulty opposed to the advance of the attacking force.

Other modifications are necessary in the offensive details of field-works to protect the interior from curved fire. Covered shelter places must be excavated under the banquettes; and where, for want of time and materials this is impossible, holes must be excavated at the back of the parapet to enable the defenders to remain passive when necessary.

These shelters render the employment of many more laborers possible, and accelerate the completion of works, and they are the more necessary, as the block-houses and redoubts of the past are now rarely possible in the time available, and, even if it were possible to construct them, they would, under the heavy converging artillery fire which would now bear on them, fail, with their restricted and exposed internal areas, to answer their old purpose.

The manner in which the walls of the Mottegiana work at Borgoforte, and more recently of the forts of Kars, were damaged to the very base, was sufficient to show how untenable the centre of the terreplein or any part of the interior of a work not protected against indirect and curved fire must soon become under the artillery fire of the present day. The importance, therefore, of providing for the rapid construction of covered shelter within a work is apparent, and the labour required to do this may be utilized by establishing a double row of fire, by forming a small covered way on the counterscarp, according to the idea of Rogniat, or with arrangements similar to those recently adopted by the Turks in some of the Plevna works.

The increasing destructive power of artillery places the defensive power of a work more than ever in the tactical conditions of the site.

Of the three fundamental types of works, the bastioned, the indented, and the polygonal, the latter tends to prevail in our day. Its simplicity renders it specially adapted for field works, and, with a well-considered design, it is possible to align most of the faces so that they cannot be enfiladed; it is the most easily adapted to the ground, and increases the distant defence in the highest degree, and, although this may be at the sacrifice of the near defence, such a construction accords with the exigences of modern tactics, because it adds to the power of embarrassing the enemy and, holding him at a distance from the front, allows time for the concealment of movements necessary for so massing bodies of troops as to enable them to act on the defensive, at the decisive points, at the opportune moment.

The bastioned or indented traces may be employed for isolated posts, where a prolonged resistance and a close defence are required.

The systems may occasionally be employed together; the polygonal in the front faces, and the bastioned to close the gorge where it is thought the distant defence might fail and the near defence assume much importance.

The war in the east has proved that it is not impossible for resolute and well led troops to take a modern field work by assault, although well constructed and defended. But this is difficult when time and circumstances permit of the proper profile being given to a work, and when accessory defences are employed.

Such accessories either add to the means of the defence, or create obstacles in the path of the attacker, often invisible at a distance, which disconnect his order of advance, diminish his *élan*, keep him longer in the dangerous zone, and make his descent into the ditch and escalade more difficult. The first class include stone fougasses, mines, rifle pits, (so much used at Sebastopol, in America, and during the Eastern war); and the second, the advanced ditch, the glacis, *trous de loup*, *abattis*, *chevaux de frise*, pallisades, stockades, bushes, stakes, wire nets, &c. With the exception of the last named these defences are of ancient origin, but with the modern rapid fire, their advantages have greatly increased. Wire nets have only recently come into vogue, since they were used at Duppel, and at Charleston in the American war. They are simple, expeditiously constructed, and very difficult to destroy.

Lecomte relates that at Knoxville, the Confederates having bravely reached the Federal works, under a hail of projectiles, were arrested within range of grape by every kind of obstacle, and among others by an invisible wire barrier, and that they lost in a few moments 700 men, against 20 only on the Federal side, and were compelled to retire.

Brialmont is of opinion that every force should in future carry coils of wire with it, and that this will enable them more rapidly than by any means to create an obstacle against horses or men. It would seem that this proposition is particularly applicable to Italy, where the numerous hedges and rows of trees present everywhere the means of making defensive position.

Field works, connected by shelter trenches, with accessory defences, and including the special strengthening of important tactical points (villages, isolated buildings, woods, &c.), will combine to constitute the defences of future battle-fields. The increased mobility of armies will, however, shorten the time which was formerly generally available for strengthening a position, and the time will often be so short that an unfavorable position must be taken up. And, considering that incomplete fortifications may, morally and materially, prove more hurtful than useful, recourse should never be had to works which there is no reasonable certainty of being able to complete in time, and their construction should be so regulated as to present a certain resistance from the first, and to allow of successive strengthening.

The greater range and accuracy of fire, both of field pieces and rifles, has, as a result, a diminution in the numbers of large field works necessary along a front, and this compensates to some extent for the short time usually allowed.

According to modern tactics, artillery should not be dispersed as formerly, but the guns should be massed in a few commanding positions, so as to converge obliquely from the flanks over the entire front. An essential condition of efficiency is the exact appreciation of the distance, and, if this is known, neither the objects aimed at nor the positions of the batteries should be changed oftener than can be helped, and thus the critical and dangerous periods of inactivity to which the pieces are always liable when limbering up and moving to new positions under fire will be avoided. The superiority of the effects gained by the Prussian artillery in 1870-71, must be ascribed to the constant observance of this maxim.

In the same campaign, in consequence of the small range of the Prussian rifles relatively to that of the Chassepots, the guns were often pushed too far forward. This was especially the case at Vionville and Gravelotte, where several batteries united established themselves for some hours in advanced positions, and sometimes, as at Armanvilliers, they were nearer to the enemy than their infantry supports. But this was done with great losses, and, although (for the reason given) the Prussians adopted such a course, they admit it was very hazardous, and now hold that, on ground only slightly broken, artillery cannot henceforth maintain itself against infantry in position, if it be not protected by an infantry escort advanced beyond its flanks.

It is considered that elevated emplacements in the interior of field works for guns "en barbette" are not compatible with the short time at disposal, and that guns should be assembled outside behind proper expeditous cover which has the advantage, according to experiments which have been made, of stopping fifty per cent. of the enemy's projectiles.

Brialmont, to remedy the long time required for the construction of emplacements, proposes to place the batteries under cover in front of the trace of the works, and to continue the construction of the parapets and emplacements, after which he would retire the pieces into the interior of the work through gaps left, and then, occupying the battery trenches with infantry, these would become flanking caponiers. But this expedient is inapplicable to works with short faces, it is opposed to the simplicity now sought for in field fortification, and the construction of the works could not progress with the speed necessary, under the fire which the external batteries would be sure to draw upon them.

The author of the paper advocates the adoption of the ideas of Rogniat and Pidoll as most in accordance with modern tactics. These writers consider that field works open at the gorge, or large buildings in a state of defence, should occupy the salient points of a position, and that the artillery should be placed more in rear in selected positions towards the centre of the intervals, protected by troops covered by shelter trenches, with abattis or other accessories of a more or less offensive character. Brialmont, agreeing generally with Rogniat and Pidoll in a preference for open works, quotes several historical examples to show how necessary it is that such works should be protected at their flanks and gorges by accessory defences to secure them against surprise. And, remembering the Napoleonic precept that no rule in war should be absolute, he shows where closed works, armed with the heaviest artillery, may still be opportune at points of primary importance on the flanks, or on the line of retreat. These latter should protect the retreat, and the bodies of troops occupying them should be prepared to be left unsupported, and, if necessary, sacrificed for the general safety.

Referring to fortified battle fields, Brialmont lays down that every fortified camp should have a defensive as well as an offensive position. This is, indeed, a consequence of the high principle of war which fixes the secret of victory, strategically and tactically, in the power of applying a concentrated and superior force at the decisive time and place. It also supports the principle previously referred to, that field works should be designed so as to assist the attack as well as to maintain the defence. But yet, a well-marked distinct offensive and defensive camp combined in nature, not requiring the exercise of art to better prepare it for its purpose, must be considered exceptional.

The defensive portions of a position will be found in various parts of it, but more properly in the centre, because defence manœuvres on the flanks require a moral and numerical superiority, while grand attacks on the centre are more difficult to make.

An example of a fortified camp in which the defensive part was quite distinct from the offensive, the former comprising the right flank and centre, while the latter extended to the left, was seen at Caldiero in 1805. Gravelotte was a recent example; in the front of the 2nd and 3rd French Corps, from the form of the ground, the Metz works and the shelter trenches constituted a good defensive camp, while the front of the 4th and 6th Corps was a good offensive position. At Gravelotte, however, Marshal Bazaine, attributing to the enemy an intention diametrically opposed to the true one, and fearing to be cut off from Metz, held his best reserves behind his left wing; when, if they had been found on the right at Roncourt and St. Privat at the right time, and had been vigorously employed, they might, perhaps, have been able to decide the fortunes of the day differently.

The author thinks that fortified villages are less fitted than in the past for a prolonged resistance, and may be a source of danger; and that it may be in future preferable to strengthen large detached buildings, when they lend themselves readily to the defence, than to occupy villages. For example, while the taking of the Castle of Geissberg, in the action of Weissenburg, was difficult, and cost the Prussians many men, there are not, says the author, many recent examples of the defence of a village so effective as to have compensated for the extraordinary losses; and he even doubts the accuracy of observation of writers in the historical examples which have been quoted from former wars to demonstrate the contrary, and, at any rate, asserts that their reasoning is inapplicable to the cases which may occur in the present day.

It may, however, be absolutely necessary to occupy villages in consequence of the place they occupy on a position; in such a case, it is not necessary to fortify the entire circumference, but only the part exposed to the attack. The defence of a village should in future be based on an external detached enclosure constituted of batteries and well-arranged field works, connected by trenches, with abattis and other obstacles. In the interior only houses or groups of houses more particularly adapted for defence should be occupied, and the action, instead of being a successive defence from house to house, should be reduced to a street fight by means of barricades and obstacles. For the redoubt, a strong building commanding a wide space should be selected; the buildings round it should be demolished. This building should be so placed as to command the line of retreat, and when a suitable building fulfilling these conditions cannot be found, a redoubt or field work should be thrown up instead of it. To defend a village, there should be one man at least, and two at most, for every pace of the external circumference, half of these should be employed for the perimetral and internal defence, and the rest should form a reserve.

The engineers are instructed in peace time in all field constructions, and the practice of the theories they learn is their primary use in war. The author is of opinion, however, that *all* infantry should be trained in the construction of hasty works, and that sufficient tools should be furnished to them to enable them to entrench themselves promptly. If this be not done as regards the men, there seems little practical end in the training which all infantry officers have to undergo, such training being according to the view of Frederick the Great an indispensable part of their military instruction. With the frequent necessity which now arises for the employment of field fortifications, the sapper companies cannot be in the majority of cases at hand, and, indeed, if infantry were trained to construct alone the hasty works which are, after all, the simplest forms of field fortifications, the sappers would be more usefully employed in the execution of the complicated works which they are specially trained for.

E. R. J.

# PAPER VI.

## THE

# BATTLE OF LOVCHA.

*22nd August (3rd September)*, 1877.

TRANSLATED BY LIEUTENANT A. O. GREEN, R.E.

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FROM THE *Revue Militaire de l'Etranger.*

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AFTER the second battle of Plevna, the Russian head quarter staff had, for the time being, to abandon its vast designs and extended operations in order to turn to more pressing affairs. It was, in fact, obliged at all costs to call to account the audacious enemy, who had just come from Widdin unawares, and encamped at a few *versts* distance from the Sistova bridge. Emboldened by two successive victories, Osman Pasha was a perpetual menace, which paralysed all operations, and the entrenched camp of Plevna, a stumbling block, which put a drag on all the strategy of the campaign. Thus, we see, after the battle of the 30th July, all offensive movements cease upon the circular front of operations, which extends from Rustchuk to Selvi and Lovcha, *viâ* the Lom and the Balkans; the head quarters approaching the theatre of the decisive struggle by degrees, and all the available forces concentrating on Plevna under the orders of Prince Charles of Roumania, who was appointed Commander-in-Chief of the so-called army of the West with General Zotoff as his chief of the staff.

During the whole of the month of August, Osman Pasha and his adversary Prince Charles were making preparations for the desperate conflicts which were to constitute the third battle of Plevna. It was in this interval that the different battles fought in Bulgaria took place—Shipka, Ayaslar, Lovcha, Katselevo, Shalevitsa, &c.

Either from prudential motives, or from want of the initiative, Osman Pasha did not attempt to push his successes of the 20th and 30th July, and the confusion which occurred on the 31st July, at the Sistova bridge, was not due, as has been wrongly stated, to the arrival of the Turkish advanced guards. On the 19th and 31st August only Osman Pasha took the offensive and made, in a certain fashion, a great sortie on Shalevitsa and Pelishat. This attempt was repulsed, but it showed the Russian staff, however, how difficult the task imposed upon the army of the west was going to be.

Before reconducting the reader to the intrenched camp of Plevna, which was at this period of the campaign the principal objective point and key of the situation, we will lead him a few leagues in a more southerly direction, to Lovcha.

Besides the official reports upon the battle of Lovcha, which was a bright exception in a series of dark and undecided, if not unfortunate affairs, supported with great stoicism by the Russian armies, we can profit by the very interesting reflections of one of General Skobeleff's staff officers, Captain Kouropatkina. These *Battle-field Impressions* refer specially to the battle of Lovcha, and the attack on the *Montagnes-Vertes* (the *mamelon vert* of this second Sebastopol).

The operations against Lovcha, which were intrusted to Major-General Prince Imeretinsky, had, says the *Invalide Russe*, been recognised necessary to restrict Osman Pasha's radius of operations, and to cut his communications on this side with the country to the south of the Balkans, from which he was drawing all his reinforcements and provisions, &c.

Prince Imeretinsky's detachment, which was formed from the army of the west, consisted of an infantry strength of two divisions, the brigade of Cossacks of the Caucasus, some sotnias of Don Cossacks, and a numerous artillery.

"On the 20th August," says General Imeretinsky in his report, "General Skobeleff left, as the advance guard, the position which he was occupying upon the heights of Kakrina, to go to the *Spring*. (See *Plate*, and for the composition of Skobeleff's advanced guard, the report of General Skobeleff given further on.)

"General Skobeleff was ordered: 1st, to capture the heights in front of Lovcha in order to allow our batteries to occupy them; 2nd, to execute all the necessary preparatory works, to reconnoitre the positions, mark out the distances, fix the number of guns which could be placed in battery to cannonade the enemy's positions, and finally, if it were possible, to dig shelter trenches and raise epaulments.

"Then the remainder of the troops were directed from Selvi on Lovcha by the highway, as follows:—

"On the 20th August the 2nd brigade of the 2nd infantry division took up a position at Kakrina.

"Foreseeing the difficulties of moving all the detachment by a single road, and the necessity of arriving at daybreak at Lovcha, the 2nd brigade of the 3rd infantry division, with three batteries of the 3rd brigade of artillery, commenced its march on the 20th, at 11 p.m.; at 2 a.m. on the 21st the 1st brigade of the 2nd infantry division, and at 4 a.m. on the same day, the brigade of Chasseurs did the same.

"The brigade of Cossacks of the Caucasus received orders to move upon Iglau to watch the Plevna road, and two sotnias of Don Cossacks, 30th Regiment, guarded the communications between Trojan and Selvi, and the issues from the mountains."

Thus the troops of the detachment arrived before the Turkish positions at Lovcha in two principal columns; the one on the right commanded by General Dobrovolsky, and the one on the left by General Imeretinsky in person, and here General Skobeleff, sent as the advance guard, plays the chief part. We will follow the movements exclusively of the left column, and will reproduce at once the report of General Skobeleff to the chief of his detachment.

### Report of Major-General Skobeleff, of His Majesty's Suite, to Major-General Prince Imeretinsky, of His Majesty's Suite, Commanding the Detachment.

"In accordance with the orders of the Chief of the Staff of the army of operations, dated 18th of August, No. 1065, my detachment formed part of the troops under the command of your Excellency, intended to operate against the town of Lovcha.

"In pursuance of your orders of the 19th of August, my detachment, which was posted in the fortified position of the village of Kakrina, upon the road from Lovcha to Selvi, should have commenced the movement upon Lovcha on the 20th of August. With this object, firstly, the 64th Regiment of Kazan, the 1st battalion of the Schouya regiment, the 2nd battery of the 16th brigade of artillery, a detachment of sappers, two sotnias of Kouban Cossacks, and a squadron of His Majesty's escort, under my immediate orders, were to take up their positions on the same day, near to the *Spring*; secondly, ten sotnias of the brigade of Cossacks of the Caucasus, and the horse artillery battery of the Don, moved through Tipova upon the village of Iglau, in front of which they took up a position.

"At 2 o'clock in the afternoon, on the 20th of August, the troops under my orders had reached the *Spring*, and, without halting there I personally reconnoitred the heights A and B (see sketch), which formed our first position against Lovcha. I made out that the height A was occupied by the enemy. Two guns of the 2nd battery of the 16th Artillery brigade were placed in position against this height on the main road, and the 1st battalion of the Kazan regiment was directed against the height with the object of carrying it. The height was carried, and as it seemed of importance for the following day's battle, the 1st battalion took up its quarters there for the night; the 2nd battalion of the same regiment, the 1st Schouya battalion and the battery occupied the slopes as a reserve to the 1st battalion. All night long, the skirmishers of the Kazan regiment dug themselves rifle pits and shelter trenches, and on height B epaulments for 24 guns were constructed, which were besides covered in front by shelter trenches for skirmishers. During the same night, the 2nd battery of the 16th artillery brigade was taken by hand labour to the rocky summits of height B (slopes of 35° in certain places), and as early as 5 a.m. this battery forced the enemy to evacuate certain parts of the height A, upon which they had made intrenchments of a strong profile. The Kazan regiment having captured these intrenchments, it became possible for me to choose a position for four more batteries. During the night of the 21st and 22nd, we were able to place upon height A, thanks to the exertions of the infantry, the 2nd and 4th batteries of the 2nd artillery brigade, the 3rd battery of the 3rd brigade, and Colonel Dykhoff's battery of the 9th brigade of artillery. The 1st and 3rd batteries of the 2nd brigade were taken to height B. The Kazan regiment and the Schouya battalions remained in their first positions.

"Lieutenant Kozello of the Kazan regiment directed all the works of fortification, and placing the batteries in position upon the heights A and B.

"Conformably with the dispositions of your Excellency, I had the left column under my orders composed as follows:—the Kazan regiment; the 1st battalion of the Schouya regiment; the 1st brigade of the 2nd infantry division; the squadron of His Majesty's escort; the 1st sotnia of Kouban Cossacks; all the 9-pr. batteries of the detachment; the 4th battery of the 2nd artillery brigade; in all 10 battalions, 1 squadron, 2 sotnias, and 56 guns. I issued the following disposition and order to the troops about the coming battle:—

"'*Disposition for the Troops of the Left Column who are to attack the Town of Lovcha.*

"'*Composition of the Column.*—1st brigade of the 2nd infantry division, the Kazan regiment, the 1st battalion of the Schouya regiment, all the 9-pr. batteries, and the 4th battery of the 2nd artillery brigade, the squadron of His Majesty's escort, the first sotnia of Kouban Cossacks, and the 2nd sotnia of the Vladikavkaz Cossacks. Total: 10 battalions, 56 guns, 2 sotnias, and 1 squadron. All the batteries to take up positions in accordance with the instructions of Staff Captain Kouropatkina.

"'The 1st brigade of the 2nd infantry division will hold itself in readiness behind the height on which is placed 'the *fortunate* (*l'heureuse*) battery.'

"'The Kazan regiment will keep its present position.

"'The 1st battalion of Schouya will join the Kazan regiment.

"'The escort of His Majesty and the two sotnias of Cossacks of the Caucasus brigade will keep their positions, and await orders.

"'The point of attack and its direction will be pointed out at the proper time and place, during the preparation by the artillery.

"'Fire will be opened at 5 a.m. against the *Montagne Rousse* (red hill), and the battery commanders will regulate their fire with accuracy, and without haste.

"'Care must be taken to see that the men have biscuit, and receive, towards daybreak, half-a-pound of cooked meat.

"'As there is water in rear of the column of attack, it will be well to tell off detachments strong enough to supply the troops in the first line with water, when the want of it makes itself felt.

"'The positions of the field hospital, the train, and the parks, as well as the fighting dress, are pointed out in the general dispositions.

"'I shall be found in person on the left flank of the column under my command, near the Kazan regiment. The *Sotniki* (lieutenants of Cossacks) Verechaguine, Geitoff, Gouteleff, and Lieutenant Lisovsky, will hold themselves at my disposal.'"

"'*Orders to the Troops of the Column under my Command, for the 22nd August*, 1877.

"'The chief part in the first period of the battle about to take place belongs to the artillery. The order for attack will be communicated to the battery commanders, who are recommended not to spread their fire. When the infantry advance to the attack, they are to support them with the whole power of their fire. The greatest attention is necessary; the fire is to be redoubled when the enemy brings up his reserves, and it should reach its extreme limits when the attacking troops are stopped by any unexpected obstacle.

"'When the distances allow of it, shrapnel is to be fired at the intrenchments and troops.

"'The infantry should avoid disorder during the action, and not confound the offensive march with the charge. It should not forget the duty sacred to all: 'to help its neighbour (comrades) at all risks and hazards.'

"'It should not fire away its ammunition uselessly. It should recollect that the ground makes the re-supply of cartridges difficult. The importance of order and silence during action is again called to the minds of the troops.

"'The troops should only cry *hurrah* at the moment when the enemy is really within reach, and when they can throw themselves upon him with the bayonet. I recall to the men that the losses in a properly managed attack are trifling, whilst retreat, above all when it takes place in disorder, terminates in great sacrifice and in shame.

"'This order, as far as it concerns the infantry, will be read to all the companies.'"

"On the 22nd of August, at 5.30 a.m., the troops were already in their positions for the battle, and, in spite of the difficulties of the ground, in remarkably good order. This we owe to the energy, experience, and activity of the Captain on the staff, Kouropatkina, who was sent by me: first, to trace the field works to be constructed, and, secondly, to post the artillery and its ammunition waggons secretly during the night, and then to place them under cover in the selected positions.

"In accordance with your orders, the cannonade opened upon the heights A and B. The enemy replied to our 56 pieces, and did so with success, thanks to the range and accuracy of his guns, which were superior to ours. Thus, the four 9-pr. guns in the *Prince Imeretinsky* battery were unable, in spite of the energy and skill of their commander, Lieutenant Doubassoff, to silence an enemy's battery of two guns, which was opposed to them. The effect of our artillery on the infantry occupying the epaulments of the *Montagne Rousse* was very deadly. The preparatory fire lasted from 5.30 a.m. until 2 p.m., and it was only then that your Excellency decided t give the signal for attack. The very small losses suffered by ou columns whilst they were advancing to the assault of the enemy's first line show how useful the fire of our artillery was against the Turk's in actual warfare, and how important the period of preparation by artillery is for all attacks directed against fortified and armed positions.

"The troops under my command attacked the *Montagne Rousse*, and heights 2 and 3. The Kazan regiment carried the *Montagne Rousse*. The attack was conducted as if on parade, with bands playing and colours flying. The commander of the regiment, Major-General Tebiakina, marched with the battalion at the head of the column, setting an example to his regiment, during the whole continuation of this warm affair.

"The *Montagne Rousse* was no sooner captured than it was crowned by the 5th battery of the 3rd artillery brigade, which opened fire upon the redoubt placed in rear of the town of Lovcha. The height itself was occupied by the 1st battalion; the 2nd and 3rd battalions advanced along the highway upon the town and took it rapidly; they occupied the outskirts, and opened a very hot fire upon the enemy. The attack of the Kazan regiment was supported by the 1st and 2nd battalion of the Pskoff regiment, and the 5th and 6th batteries of the 2nd artillery brigade, sent from the general reserve by your Excellency.

"Heights 2 and 3 were taken by the 5th brigade of the 2nd division, under the command of Major-General Razguildeff.

"Having captured the town, I set about preparing the attack upon the enemy's second line, situated on the left bank of the Osma, with a redoubt of very strong profile, which served him as a retrenchment (*réduit*).

"With this object, besides the batteries placed upon the *Montagne Rousse*, two batteries, the 6th and 2nd of the 2nd Artillery brigade, were placed in position upon the road.

"During this time, besides the Kazan Regment, the three battalions of Iskoff, the 1st Schouya battalion, and the Revel and

Esthonian regiments, sent by your Excellency, entered the town and prepared for the attack.

"At 5.30 p.m., being convinced by certain indications that the artillery preparation was sufficient, and having given the infantry their needful repose, I decided to begin the attack of the enemy's last position.

"The right wing of the Turkish position was considered the most important, and I directed the chief efforts of the attack upon that point. The Kalouga regiment, a part of the Liebau regiment, and some handfuls of men of the 10th battalion of chasseurs attacked the left wing. Two battalions of Iskoff (the 1st and 3rd) formed up in echelon on the right, attacked the centre of the left wing. They were supported by the 1st Esthonian battalion, and in addition, the Revel regiment was held in reserve on the left wing.

"The troops, under a heavy fire, advanced against the steep heights occupied by the enemy.

"In spite of the heavy losses which they sustained, the greater number of the battalions, which were formed in two lines of company columns, advanced in good order, drums beating, and colours flying. A momentary disorder was observable in the 1st Iskoff battalion at the moment when its brave chief, Colonel Kinssoff fell; but thanks to the efforts of the officers, the battalion was again brought into order, and marched in advance of the others. The first line of trenches was quickly carried, and then a part of the reserve was thrown forward to the assault of the redoubt. The commander of the Kalouga regiment, Colonel Eljanovsky, with his soldiers and some men of the Liebau regiment, and Captain Hübert von Greifensfeld, of the 15th battalion of chasseurs, with 26 soldiers, entered the redoubt.

"After a few moments of terrible fighting, the defenders of the redoubt were exterminated. The enemy made no stand and fled along the whole line.

"The brigade of Cossacks of the Caucasus pursued them for seven versts, and sabred 3000 men.

"The losses on our side exceed, in killed and wounded, 1500 men.

(Signed) "SKOBELEFF,

"Major-General of His Majesty's Suite."

The reader will have been struck, like ourselves, with the precautions revealed in the orders of General Skobeleff; the necessity for carefully preparing the attacks, for not beginning them too soon, and for not making an abuse of the *hurrah*. For the first time, we see in an official document, the commander desire (*inviter*) the troops to put a check upon their burning impetuosity and recommend a little more *method*.

It is one of the most enterprising generals of the *Asiatic school*, one of those who emulate the glory of Souwaroff, in its purest form—his military *coup d'œil*, his reputation as an energetic soldier, and, above all, his prestige with the troops—it is, we say, one of the youngest and most impetuous of the generals of the Russian army who holds this language.

The lessons of experience have borne fruit, and we are already able to establish a sufficiently broad interpretation of Souwaroff's favourite manner.

But all our reflections upon the Lovcha affair would be without colour or savour, beside those which have been announced at the commencement of this article, and we hasten to pass the pen on to Captain Kouropatkina, General Skobeleff's aide-de-camp and right hand man.*

*Notes by Captain Kourapatkina.*

"The hasty notes which I submit to the readers' attention, are the result of my personal observations of the method of action of the Russian artillery and infantry, and their effects during the battles of Lovcha and Plevna.

"Written without any preconceived idea, and without sequence, these notes only constitute in my opinion the rough material, from whence it would be possible, with time, to draw a certain number of conclusions. In short, as they are collected under conditions little favourable to literary work, they are very far from arrogating that title, and I would beg the reader to please remember this.

"At the time of the offensive movement made on the 19th (Russian style) August, by General Skobeleff's detatchment, with the object of taking up a position upon the heights surrounding Lovcha, the two battalions of the Kalouga regiment, which were in the first line, advanced with their lines of skirmishers much too dense, whilst the supports were kept at a great deal too close a distance. This fault is constantly recurring and always occasions needless losses.

"The necessity for rapidly fortifying the points which we had just occupied before Lovcha, made us feel the insufficiency of the in-

* Captain Kouropatkina has since been promoted to lieutenant-colonel, and chief of the staff of the 16th Division, commanded by General Skobeleff, promoted lieutenant-general.

trenching tools at our disposal. We were obliged to collect those of a whole battalion in order to form working parties. When the works were finished, the tools did not all return punctually to the troops who had lent them.

"The presence of a detachment of forty sappers under a non-commissioned officer would greatly facilitate the execution of works. The officers who pass out of the Military Colleges would make excellent directors of field fortification works.

* * * * *

"When they march against the enemy, the leaders of the various bodies formed should not loose sight of the feeding of their men. In the absence of this care, the commander of the detachment is himself obliged to make all the necessary arrangements for sending supplies of water to the occupied positions, to give the orders for having the food prepared in rear of the line of battle, and finally, to see that this food is carried to the combatants,

"There is always, even in the hottest fights, during the night a sort of lull, during which it is always possible to have the soldiers' food carried either by men or in waggons. In extreme cases one can limit oneself to the distribution of the ration of cooked meat.

* * * * *

"At the battle of Lovcha, the troops, from their first entry into the town, came within the zone of fire of the last line of the enemy's intrenchments. The infantry began rapidly to show signs of disorder. Instead of occupying the outskirts of the town and choosing positions from whence the enemy's fire could have been replied to with advantage, both companies and individual men massed themselves in the street, without formation, and hugged the houses or lay down in the ditches. Only a few officers showed signs of intelligence and the power of taking the initiative, by collecting the men belonging to different companies and making them occupy detached houses, from whence they could open fire.

* * * * *

"Thanks to the enormous quantity of cartridges fired by the enemy, their fire made us suffer heavy losses at a distance of 2,000 paces.

* * * * *

"Nothing is more difficult than to keep troops in hand when assaulting a town. Out of two battalions of the same regiment which entered Lovcha, the colonel was only able to rally four companies round him. Five others rallied round the reserves intended to carry out a decisive attack against the enemy's right wing, and the sixth (a light infantry company), upon the initiative of its commander, backed up the attack of the Kalouga regiment against the left wing.

* * * * *

"At the time of the attack upon the enemy's position at Lovcha, the objective of one brigade was the left wing of the position.

"The brave commander of the brigade received a wound which placed him *hors-de-combat*, and the regiment continued to advance in the direction primarily pointed out. The Kalouga regiment of infantry marched in front having its commandant at its head full of courage and animation. On approaching the zone of the enemy's fire, the regiment skirted the vineyards which cover the banks of the Osma, reached a point favourable to the passage of the river (nearly as high up as the left wing of the enemy's position), then single men commenced to gain the open in the valley of the Osma, and moved under a heavy fire against the enemy's position. Other soldiers followed the example of the first, and soon some hundreds, having passed the ford one by one, rushed onwards towards the enemy across the heaps of pebbles collected by the floods, leaving everywhere behind them a large number of killed and wounded.

"In the valley, there was a distance of from 500 to 600 paces completely without cover to cross, and only affording as a temporary shelter, a mill surrounded by a few dozen of trees.

"A portion of the men crossed the valley in a single rush; the others taking advantage of the heaps of pebbles piled up by floods, lay down behind them; the stragglers joined these latter by degrees in such a manner, that in certain places there were formed compact groups of soldiers lying down.

"This shelter only afforded them a very feeble protection against the fire of the enemy, who was established at about 2,000 paces distance, and firing at very great angle of depression. The men lying down saw that the bullets still reached them; the most courageous, therefore, got up, and rushed forward at a run, gradually followed by their comrades, all trying to gain the protecting mill. And, in the meanwhile, there was nothing which obliged them to cross this space. It would have been sufficient to have continued advancing along the vineyards, passing into the suburbs of the town, to debouch in the end at the mill in question. Instead of following the cord, they ought to have followed the arc.

"About half an hour after the commencement of the offensive movement, the mill and its surroundings were occupied by several hundreds of men, whose numbers increased every moment. The shelter became insufficient and the losses continually greater.

"The commandant of the regiment wishing to carry the mass of men forward, when they had not yet had time to recover their breath, caused the charge to be beaten and rushed to the front in person. He was followed by a few soldiers, but the latter, seeing that their comrades did not move, retraced their steps.

"A young officer vainly exhausted himself with crying in a hoarse voice: *Forward! Hurrah!* brandishing his sword. The mass of the troops did not feel themselves inclined yet to follow his footsteps; besides, he had scarcely advanced a few paces, accompanied by several soldiers, when a bullet struck him mortally. A portion of those whom he had carried with him, met with the same fate, and the others took shelter in the roadside ditches.

"After a short time this crowd regained their breath; the emotion experienced after the first rush gradually wore away; they were again ready to commence the onward movement.

"First, a few brave men accompanied by an officer made a rush forward of 50 or 60 paces, some screened themselves behind the trees, others dragged themselves along the ground.

"They were set going; little by little the mill was emptied, the men leaving either in groups or singly.

"There still remained 1500 paces to reach the enemy's trenches. A rain of lead descended upon the assailants without stopping their march. Their comrades of the same regiment were advancing behind them; on the right were men belonging to the chasseur battalion, with a small party of soldiers of the neighbouring regiment, the whole led by two officers; on the left, a line formed by a light infantry company; further on, in the same direction, were to be seen dense masses of troops in the act of making their dispositions of the battle. On turning round, each one of the assailants seeing his own people in numbers on every side, was sure of being supported with little delay, and the hope of success momentarily increased.

"Already accustomed to the enemy's fire, single men followed their onward march without making too much use of the cover which came in their way.

"Several mounted officers found themselves among the assailants. The brave commander of the regiment encouraged his soldiers by voice and example. Suddenly one of the riders staggered and fell dead from his horse; it was the adjutant of the Liebau regiment, who was taking part in the attack of the Kalouga regiment. Another rider, a battalion commander, rolled over on the ground with his horse. Officers and soldiers were seen falling around, the groans and cries of the wounded were to be heard on every side, but nothing of all this could stop the impulse *(élan)* when once it was given.

"The men who were leading suddenly came across, at 700 paces from the mill, a deep ravine with steep banks. Those who arrived first stopped; those following increased the crush, which did not fail to make a certain number of victims. Many of the wounded fell into the water and were drowned.

"In the meantime, those who had kept cool soon found out a more practicable descent, and reached the bottom of the ravine by sliding or rolling down the slope. The depth of the water, which has a tolerably rapid stream, did not reach above the waist. The river was crossed, and then a more difficult operation commenced—the scaling of the opposite slope. They made use of their comrades' shoulders, of their rifles stuck into the ground, and in a short time several hundreds of men were on the other side of the ravine.

"To everybody's astonishment, the fire of the Turks did not increase in accuracy as they approached them. It became evident that the enemy was beginning to be shaken. Suddenly the Turks abandoned their trenches and took to flight without awaiting the shock of the Russians. The sight of the enemy's retreat redoubled our soldiers' ardour; their *hurrahs* resounded more and more.

"Having once arrived at the first line of the Turkish trenches, our men halted and took possession of them.

"In front, upon a commanding position, a redoubt of strong profile, the last refuge of the Turks, was made out. This was itself covered by a line of shelter trenches. The enemy had not ceased his heavy, but ineffectual fire. Many of the Turkish soldiers fired after placing their rifles upon the slope of the parapet, without exposing their heads, that is to say, without taking aim.

"Our men seeing themselves collected to the number of some hundreds in the first trenches, again sent forth shouts of *hurrah!* and rushed forward. They approached the second line of trenches, and got ready for a fight with cold steel; but no, it was not to come off this time. The Turks abandoned the entrenchments and fled, some towards the redoubt, others by the Mikra road. Within the redoubt everything was in movement. Several groups of horsemen were to be seen leaving it, escorting a kind of chariot. "They are carrying off their guns!" Some were heard to cry, and our soldiers, certain of victory, made a last effort. On all sides, both soldiers and officers, scrambled over the parapet of the redoubt, whilst a sufficiently numerous body of men turned the work and went to occupy the way out, in order to cut off the retreat of those Turks who wished to fly. In the inside those of the enemy who resisted were slaughtered. The angle of the redoubt, situated between the parapet and the traverses, was encumbered with a heap of dead bodies, and men still living, piled up one upon the other. One of the officers of the chasseur battalion, who had been one of the first to force way into the redoubt, held himself modestly aloof. The battle was scarcely over, when a large number of soldiers set to work to separate the dead and the living, friends and enemies.

"From the heap in the angle of the redoubt, 103 Turks were drawn out, either slightly wounded or not wounded at all, and these were kept as prisoners of war.

* * * * *

"The first battalion of the N—— regiment, following a street in Lovcha, arrived at the end of the town, and then had to debouch, through a door pierced in a wall, on to a large square (*place*) planted with several rows of trees and swept by the fire of the enemy, who was sheltered behind entrenchments.

"The order had been given to the Colonel of the regiment to deploy one battalion in order of battle, and to commence by attacking the centre of the enemy's position with it, and to support this attack with the two other battalions.

"The colonel directed the light infantry company to advance to the front and occupy the square. These came into action to a flank, and succeeded in deploying into line in the required direction, but with very heavy losses. The line (*chaîne*) formed by the company was rather analagous to a close order formation.

"When they had once reached their appointed positions, the men and officers immediately lay down, and it was with much difficulty that they were made to get up again and go on, in order to make way for the four other companies. At this moment, the colonel, struck by a bullet was placed *hors-de-combat*. At the sight of their dying chief, a cry arose from the midst of the skirmishers "the colonel is killed"; a body of men rushed towards the door, whilst the companies which were advancing behind the skirmishing company, impressed by the loss of some of their men, and by the sight of their colonel covered with blood, turned their backs, repeating the same cry. It was with difficulty that the column was successfully reformed, the soldiers led back to their places, and the attack recommenced. The skirmishing company had not yet gained sufficient distance, when the two companies of the first line were made to advance, and immediately afterwards that of the second. At the expiration of a few minutes, the skirmishing line and the two lines of company columns intermingled, and formed only a single dense line, which advanced slowly. The worst of it was, several soldiers commenced firing, without taking aim, at more than 500 *sagends* (1166 yards) distance, and the battalion began shouting *hurrah!* as soon as it gave way. After a few steps, the men lost breath; the *hurrahs* ceased almost entirely, and only escaped occasionally from hoarse throats; the terrifying effect produced upon an enemy by a body of men charging at 100 to 200 paces, and shouting direful and threatening *hurrahs*, was completely lost.

"Here the shout of *hurrah* was far from expressing the unshakeable determination to make the enemy retire, or come to a hand to hand encounter; it only showed the desire to counteract the painful impression produced by the whistling of the bullets, and partly, also the hope of frightening the enemy.

"The other battalions were led into action in better order."

A. O. G.

# PAPER VII.

THE

# HISTORY AND GEOGRAPHY OF AFGHĀNISTĀN

AND THE

# AFGHĀN CAMPAIGNS OF 1838-9 AND 1842.

BY MAJOR H. HELSHAM JONES, R.E.

*A Course of Lectures delivered at the R.E. Institute, Chatham, December* 1878.

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THE following Lectures, which were delivered in December, were prefaced by a short introduction, in which Major Jones disclaimed any pretension to being 'an authority' on the subject of Afghānistān. He explained that the proposal to take the Afghān campaigns of 1839-42 as a subject for lecturing was made before the repulse of Sir Neville Chamberlain's mission brought Afghānistān into special notice. He continued, 'During my service in India I naturally had my attention turned to the campaigns of 1839-42, and I had been much struck with a passage in Colonel Charles Chesney's Introduction to the Essay entitled "Waterloo Lectures," which is as follows :—

'It has not unfrequently occurred that the features of national policy bear the impress of false current notions of military events. Our own recent Indian history affords a very striking instance of this truth. Rather more than a quarter of a century since (published in 1868) we occupied Afghānistān, to anticipate Russian intrigue on our north-western frontier. The country was held for us by three separate brigades of troops, each with distinct cantonments and administration. An insurrection took place at the capital, spreading soon to other districts, and the force at head-quarters, overcome rather by the imbecility of management than by the strength of the enemy, perished absolutely with all its camp followers in the attempt to retreat. The other two brigades held their own with perfect success, and maintained our hold of the country, until, being reinforced, they reconquered it with ease. We had thus lost about one-third of the original army of occupation: 4,500 men in fact. Unfortunately, in writing of such a disaster, there is a tendency on the part of the historian to magnify his office and to give the event undue proportions, and the school of writers who seek effect rather than strict truth have made the Afghān war their own. Hence it has been usual to add to our actual losses the swarm of followers who accompanied the combatants that fell, and to keep in the back ground the true proportion of the latter to the forces that held out. So that if twenty fairly informed Englishmen were now interrogated on the subject, nineteen would probably unhesitatingly admit such statements as that "all our army was destroyed," or that "our terrible loss of 16,000 men in Afghānistān shook our prestige throughout the East," and the moral effect of the disaster upon our policy has ever since been magnified threefold.

'I thought therefore that if I could give my brother officers some connected account of these campaigns in a plain, matter-of-fact sort of way, it might be useful to them in their subsequent career—especially to those who were to serve in India.'

After some further remarks Major Jones went on as follows:—

'The subject of this evening's lecture is the geography of Afghānistān, with a short notice of its political history. The politics of an Asiatic state are generally rather uninteresting, and Afghānistān, I fear you will think, offers no exception to the rule. But the causes which led to the war of 1839 depend so much upon the relations between the past and present dynasties of the country, that it is necessary to make an attempt to explain them. The diagrams (*see* Plate III.) of the Saddozai and Muhammadzai families, will, I hope, render them tolerably intelligible.

'With regard to the maps, or rather diagrams—that in Plate No. I. is on the scale of 192 miles to an inch, and shows the country from the Caspian Sea on the west to Calcutta on the east, from Bukhāra on the north to Bombay on the south.

'The diagram in Plate No. II. is on a scale of 144 miles to an inch. It has been made to show the general features of the country we call Afghānistān. All details are omitted so as to bring out the main lines of mountains and the chief valleys with the more distinctness.'

## Geography of Afghānistān.

Before proceeding to the description of the country let me say a few words on the spelling and pronunciation of the names. The system of spelling followed is that now known as the Hunterian, first proposed by my distinguished namesake, Sir William Jones. This system has been much opposed by partisans of the old ways—I cannot call them systems—of spelling, but it is now authoritatively adopted by the Government of India, and is followed in all official correspondence. It is not necessary to refer now to the consonants, as the sounds of those used are the same as in English (except to remark that g is always hard, no matter what vowel comes after it); only the vowels need a short notice. The following table shows the ten vowel sounds in use, and the mode of representing them in the Hunterian system. It is sometimes objected that the way of pronouncing them is for an Englishman conventional and not natural, but, to show how little ground there is for this objection, I have used none but English words to represent the sounds intended, except in the case of the 'au' for which I confess I can find no English example and have been forced to have recourse to a German one.

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| a | *A*merica . . . . . .<br>Postm*a*n . . . . . .<br>Redc*a*r . . . . . .<br>Fin*a*lly . . . . . .<br>Mainmast . . . . . .<br>M*a*cDonald . . . . . | Ghazni.<br>Harī Rūd. |
| ā | Father. . . . . . . | Kābal. |
| i | Pin . . . . . . . | Pindī. |
| ī | Calibre . . . . . . | Spīn. |
| ai | Aisle . . . . . . . | Khaibar. |
| au | The German word *frau*. | |
| e | There.<br>Auto da fe. | |
| o | Noble . . . . . . | Bolān. |
| u | Put, push. | |
| ū | Ruler . . . . . . . | Harī Rūd, Jamrūd. |
| y | is not used as a vowel . . . . | Yasīn. |

The name Afghānistān,* as we use it to denote generally the whole country which is supposed to be ruled over by the Amīr of Kābul, is almost unknown to the Afghāns themselves. They call their country Vilāyet. They also distinguish it, says Dr. Bellew, by two appellations including different portions of territory; namely, first, Kābul or Kābulistān, which includes all the mountainous region north of Ghaznī and the Safed Koh, as far as the Hindū Kūsh, limited towards the west by the Hazāra country and east by the Indus, and, secondly, Khōrasān, which includes the extensive tract of country stretching south and west from near Ghaznī and bordering on the confines of Persia.

Afghānistān may be described as consisting of a number of valleys radiating round the great peaks of the Koh-i-Bābā (or

* The termination *istān* signifies place or country—Afghān-istān, country of the Afghāns. When added to a word ending in a vowel *stān* is used thus: Hindu-stān, country of the Hindus.

mountain of the *Bābā*).* These peaks must be of enormous height, since the path to the east of them, which leads from Kābul to Bamiān, is upwards of 12,000 feet above the level of the sea. The Koh-i-Bābā is part of the great range which runs, under various designations, from the Pamīr (literally, roof of the world), the great elevated plateau of Central Asia, through the country of Afghānistān. It next forms the northern boundary of Persia from Sarakhs to Kizil Arvāt, where its peaks reach to 8,000 or 10,000 feet only, and runs on to the Caspian to the headland of Krasnovodsk. It then disappears beneath the waters of the Caspian Sea, whence it rises again at Bākū to form the chain of the Caucasus, where (in Mount Elburz) it reaches an altitude of over 19,000 feet above the sea.

The point where the range leaves the Pamīr is stated to be in about lat. 36° 50′, long. 73° 35′. From this point for about 350 miles the main range, which runs in a south-westerly direction, bears the name of the Hindū Kūsh. This brings us to a point nearly due west of, and about 60 miles distant from, Kābul. Here, a little west of the Hājīkhāk Pass, the range divides; the northern branch, taking the name of Koh-i-Bābā, runs for a space nearly due west, while the other branch runs south-east for a distance of about 60 miles. Looking first to the latter we find that it has *three* principal ramifications: one, called the Paghmān Mountains, runs south-west for about 250 miles, separating the basin of the Halmand from that of the Argand-āb; one, called the Safed Koh (White Mountains), runs eastward towards Peshāwar; whilst the third (of which at present very little is actually known) runs nearly south for about 300 miles towards Kalāt, in Balūchistān. It is this last range which throws off spurs to the eastward towards the Panjāb. These spurs tower above the Derajāt and present from the low country the appearance of an independent range of mountains which has, from the hill called the Takht-i-Sulaimān (or throne of Solomon), gained the name of the Sulaimān range. This so-called range has recently been described (by the *Daily News*) as the true frontier of India. There is, however, very good evidence to show that no such range exists. It is probably shown more correctly on the map published by Stanford and Co., after Major-Gen. Walker, than on any other map we have.

Going back now to the Koh-i-Bābā, we find that it runs west for nearly 100 miles, and then divides into two parts. The southern branch takes the name of Siyāh Koh (or Black Mountains), and after going south-west for about 70 miles turns west and runs on to the

* *Bābā*, originally father, means religious devotee. It is the name used now by a certain sect.

neighbourhood of Herāt, a distance of about 200 miles. The Siyāh Koh divides the valley of the Harī Rūd on the north from that of the Halmand on the south. Its northern slopes are steep, and the Harī Rūd runs nearly parallel to the axis of the range, whilst on the south it throws out long spurs (inhabited chiefly by the Hazāras) which push the Halmand away into a more southerly course.

The northern branch of the Koh-i-Bābā, after running north-west about 50 miles, again divides into two; the southern branch is called the Safed Koh. (N.B.—Not to be confounded with the other Safed Koh south-east of Kābul.) The Safed Koh runs due west, its northern slopes draining into the Mūrgh-āb river, and its southern to the Harī Rūd. The northern branch is called Tirband-i-Turkestān; it encloses the head waters of the Mūrgh-āb.

The ranges of mountains just mentioned form the great natural divisions of Afghānistān, which country is sub-divided by European geographers into Afghānistān Proper, and Afghān Turkestān, or the country north of the great range of the Hindū Kūsh and Koh-i-Bābā. Of the heights of the various mountain ranges little is accurately known, but the peaks of the Koh-i-Bābā and Hindū Kūsh must reach to 20,000 or 21,000 feet, and those of the range running south between Kābul and Kalāt probably to 15,000 feet in altitude.

Returning now to the system of valleys radiating round the Koh-i-Bābā, we find, working round from right to left:

1st. On the east, the Kābul valley, which sends its waters to join the Indus at Attak, and thence into the Indian ocean.

2nd. On the south, the valley of the Argand-āb, the waters of which flow into the Halmand, 100 miles west of Kandahār. The town of Kandahār lies in the lower part of this valley.

3rd. Parallel to the valley of the Argand-āb and a little south of it lies that of the Tarnak, in which is the town of Ghaznī. The Tarnak river joins the Argand-āb about fifteen miles below and south-west of Kandahār. The town of Ghaznī, however, is not actually on the Tarnak, but on a smaller river (called the Ghaznī river), which flows into the salt lake called Abistāda.

4th. The valley of the Halmand, a river which, rising in the Koh-i-Bābā, runs south-west for a long distance, and finally loses itself in the Sistān swamp. Girishk, an important town and fort 70 miles about west of Kandahār, is on the Halmand. The Halmand receives the Argand-āb about forty miles south of Girishk. The lower course of the Halmand belongs to Sistān, which will be noticed immediately.

5th. But, beginning further west, at the bifurcation of the Siyāh Koh and the Safed Koh, is the valley of the Harī Rūd, which river flows about due west by Herāt to Ghoriān. After passing Ghoriān it turns north, and is finally lost in the sands of the desert to the westward of Marv.

6th. North of the Hari Rūd valley, and separated from it by the Safed Koh, comes the Mūrgh-āb valley. The river Mūrgh-āb rises on the northern slopes of the Safed Koh, and flowing first westward and then north-west past Marv, is lost in the sands of the Kāra Kum desert after a course of about 400 miles.

These six are the principal valleys of the country of Afghānistān Proper. Besides these there are the tributary valleys of the Indus, which are also elevated valleys; the chief of these are, beginning from the north :

(1) The Kūram, which runs nearly parallel to Kābul river; (2) The Gūmal; (3) The Zhob; (4) The Bori.

Between the Kūram and the Gūmal are two small valleys, known as Khost and Dāwar, the waters of which drain into the Kūram river.

In 1838 very little was known of these valleys, and even now that the Panjāb has been a British possession for thirty years, very few Englishmen have traversed even the first. The Gūmal was explored by Broadfoot, an officer of Bengal Engineers, during the British occupation of Afghānistān; but of the Zhob and Bori valleys nothing is known except from native reports.

Afghān Turkestān, the country north of the great range of mountains, is composed of the many valleys which descend from the mountains to the Oxus. The Oxus (or Amū Dariyā), flows in that part of its course in a direction generally parallel to that of the great mountain range, and at an average distance from it, about 120 miles to the north. Between the mountains and the river lie (beginning from the east) the districts of Wakān, Shagnān, Roshān, Darwāz, Badakshān, Kundūz, Khulm, Balkh, Maimana, and others: principalities over some of which the Amīrs of Kābul have exercised sovereignty, whilst some have remained always independent.

Besides these mountain valleys there is the Sistān valley, which is an extensive tract of country, now almost desert, but possessing a fertile soil which needs only irrigation to produce the most magnificent crops. The Halmand for the last 250 miles of its course belongs to this basin, and there are besides, the Khāsh-Rūd, the Khaspās-Rūd, the Farah-Rūd, and the Harūt-Rūd, four smaller streams, all of which, like the Halmand itself, empty themselves into the Sistān swamp. This great swamp is about 150 miles long and 10 to 15 broad. It is very shallow: Ferrier says only 4 or 5 feet deep. The country is at present unhealthy and uncultivated, but seems to be capable of great development.

The chief towns of Afghānistān are:—

Kābul, with a population of about 60,000.
Ghaznī.
Kandahār, which has a population of about 40,000.
Herāt, with about 45,000.
Girishk.
Farah.
Ghoriān.
Jalālābād, about 1,000 only.

Kābul is distant 193 miles from Peshāwar (20 marches); Ghaznī from Kābul, 88 miles, or 7 marches; Kandahār from Kābul, 318 miles, or 29 marches; Herāt is distant from Kābul, in a straight line nearly due west, only 400 miles, but by an army it can only be reached *viâ* Kandahār. Herāt is nearly 400 miles from Kandahār (about 35 marches), so that the journey from Kābul to Herāt will cover at least 700 miles, and amount to at least 64 actual marches.

Kandahār is distant from Shālkot 14 marches (147 miles).

It is a common mistake of the geography books to say that a country is *watered* by many rivers, whereas it should be said that it is *drained* by them. In Afghānistān, however, as in some other eastern countries, the rivers are really the means of watering the country. The water in them is retained by dams and used for irrigation. The waters of the Harī Rūd are largely used for this purpose, and the plain of Herāt is very fertile in consequence. Little corn, however, is, owing to the defective means of transport, grown beyond what is required for local consumption. Besides damming the streams and drawing off the water, the Afghāns obtain water for their fields by means of what they call karez.*

The climate of Afghānistān is very various, as may be expected from the differing altitude of different parts of it, although the greater part is 4,000 feet above the sea. Thus Kābul is 6,400 feet above the sea; Kandahār only 3,400; Ghaznī, higher than Kābul, being 7,720; Jalālābād is 1,960 only; while Gandamak, only 35 miles above Jalālābād, is 4,600 feet; Istālif and Charīka, in the rich Kohdāmān of Kābul, are probably between 5,000 and 6,000; Herāt is only 2,650 feet; Ghoriān about 2,100.

* A karez is formed by sinking a well until water is found, and then a number of (dry) wells along the line on which it is desired to conduct the water. The bottoms of all the wells are connected by a gallery, and the water is thus conducted by a slightly inclined bed to the surface of the land it is intended to irrigate.

Shālkot (or Quetta), which, however, is not in Afghānistān but in Balūchistān, is 5,500.

It must be remembered that over all these altitudes there shines an almost tropical sun, the latitude of Kābul being about the same as that of Fez or Tripoli.

At Ghazni the snow lies for three months on the ground, the thermometer sinking to 10° and 15° below zero. At Kābul it falls to 5° or 6° below zero, and the snow lies for two or three months together. At Jalālābād the winter is as mild as in India. Gandamak, only 35 miles from Jalālābād, has, on account of its greater elevation (4,616 feet), a severe winter. The summer heat of Afghānistān is everywhere very great, except in the high mountains. At Kandahār the thermometer in summer is often above 110° in the shade, and they have hot winds. Even at Kābul (high as it is) the thermometer ranges from 90° to 100°. Afghānistān has no monsoon rains. The animals of the country are horses, camels, cows (and occasionally buffalo), sheep, goats, &c.

Afghānistān has two harvests. One is sown in the end of autumn and reaped in summer; the other sown, in the end of spring, is reaped in autumn.

Thus it will be observed that though they have, as in India, two harvests, there is only one crop off the same ground—not two, as in India.

The summer harvest gives wheat, barley, peas, and beans, and the autumn one rice, millet, Indian corn, and some other crops.

Fruits of all English sorts are excellent, also pomegranate, almonds, pistachio nuts. Fruit grown in the Kābul valley is largely exported to India. The vegetables are carrots, turnips, beet, lettuce, onions, garlic, spinage, and greens of all kinds.

Colonel MacGregor, after a detailed estimate, makes the total population of Afghānistān in 1871 about 5,000,000 souls. This is liable to a very large deduction if the population subject to the ruler of Kābul in 1838 had to be calculated. That probably did not amount to more than 2,000,000.

The division of the country by clans is of the first importance from a military and political point of view. The more important only will be mentioned:—

(1) North of the great range of the Hindū Kūsh and Koh-i-Bābā the ruling race are Uzbegs, like the inhabitants of Khīva and Bukhāra, with a large number of the ancient Persian races. The inhabitants of some principalities on the Upper Oxus, such as Wakhān and

Badakhshān, claim descent from Alexander the Great. They are not Uzbegs or Afghāns, but nothing is really known of their descent.

(2) The country about the upper valleys of the Mūrgh-āb, Hari Rūd, Halmand, and Argand-āb, is inhabited by Hazāras and Aimaks, and is known as the Hazārajāt.

(3) The Dūrānis (the royal clan) inhabit a line of country stretching from Herāt by Kandahār to Shālkot. Their country is approximately defined by a strip of 60 miles in width, extending along this line.

(4) North and east of the Dūrānis, occupying part of the Tarnak, part of the Kābul and Kūrum valleys, are the Ghilzais. Their country reaches Kalāt-i-Ghilzai on the south, the Gūlkoh (range dividing the Tarnak from the Argand-āb) on the west, the Kābul river on the north, and the range which runs along the 68th parallel of longitude on the east. It is about 300 miles long by 100 miles broad at its widest part, about 35 miles broad on the north.

(5) In Kāfiristān are the Siyāh Posh and Chitrālis, both owning no allegiance to Kābul.

(6) The Yusufzai, who inhabit the northern half of the Peshāwar valley and the hills as far as the Swat valley.

(7) Fringing the eastern spurs of the Sufed Koh are the Mohmands, Afrīdis, Khattaks, Tūris, Bangash, and others.

(8) The Wazīris stretch across the outlets of all the valleys from the Kūram to the Gūmal.

(9) Povindahs (or Lohānis), a clan of fighting traders who inhabit the triangle comprising the Zhob and Gūmal valleys, and lying between the Ghilzais, Wazīris, and Kākars. They carry on trade between Calcutta and Delhi on the one side and Herāt and Bukhāra on the other. They are partly a pastoral and partly a trading race. They always have to fight their way through the passes in the Wazīri country. Sir Herbert Edwardes says: 'I hardly ever saw a Povindah who had not one or more wounds on his body; and the loss of an eye, broken noses, scored skulls, lamed legs, and mutilated arms are almost as common as freckles in England.' They come into the Derajāt through the Ghwālari and Zhob passes. The Lohānis supplied camels on a large scale to the force employed in 1838-42.

(10) Lastly we come to the Kākars, who inhabit the country from a line joining Shāl to the Takht-i-Sulaimān southwards, coming down to the Bolān on the south and the Derajāt on the east. This tribe much molested our line of communications through the Bolān in 1838-39.

Besides these territorial clans, there are three tribes or denominations which are distributed over the country, namely:—

The Tājaks,

The Kāzlbāshis, and

The Hindkīs and Jāts.

The Tājaks are supposed to be descended from the Persians, and speak a dialect little different from modern Persian. They are addicted to fixed habitations, to agriculture, and to other settled employments. They are most numerous about the towns, composing the principal part of the population of Kābul, Kandahār, Herāt, and Balkh. They form a part of the Afghān standing army. They are Sunnīs.

The Kazlbāshis are a tribe of Persian descent. They principally live at Kābul, but are found at other places in Afghānistān. They are the descendants of 12,000 Persian families who came to Afghānistān with Nādir Shah. They constitute the bulk of the cavalry and artillery of Afghānistān. They are all violent Shīahs, and therefore unfriendly to the Afghāns. It is said that under judicious management they might have been induced to join the British at Kābul during the troubles of 1841.

The Hindkīs, who number about 300,000, are Hindūs of the Kshatri class. They are found all over Afghānistān. They are occupied entirely in trade. They are forced to pay a high capitation tax, and suffer many disabilities. Their religious ceremonies are suppressed; they are not allowed to give evidence in court, nor to ride on horseback, and so forth.

The Jāts are a race of poor Muhamadans, who possess little or no land, and are usually employed as farm servants, barbers, and sweepers. They are Sunnīs, and number about 300,000.

Colonel MacGregor's estimate of population is as follows:—

| | | | |
|---|---|---|---|
| 1. Badakshān Darwāz &c. | | 56,000 | |
| 2. Kundūz, Khulm, Balkh | | 350,000 | |
| 3. Char Wilāyat, Mamiana, Andkoi, Shabarghān and Siripul | | 237,000 | |
| | | | 643,000* |
| 4. Ahmaks | | | 250,000 |
| 5. Hazāras | | | 150,000 |
| 6. Dūrānis | | | 600,000 |
| 7. Sistānis | | | 127,000 |
| 8. Tarīns | 38,000 | | 110,000 |
| 9. Kākars | 72,000 | | |

* All north of the Hindū Kūsh.

| | | |
|---|---|---|
| 10. Ghilzais | | 276,000 |
| 11. Povindahs | | 30,000 |
| 12. Hindkis and Jāts | 300,000 each | 600,000 |
| 13. Tājaks | | 500,000 |
| 14. Kāzlbāshis | | 150,000 |
| 15. Wazīris | | 127,000 |
| 16. Afrīdis | | 85,000 |
| 17. Mohmands | | 80,000 |
| 18. Yusufzais | | 400,000 |
| 19. Chitrālis, Nīmchas &c. | | 150,000 |
| 20. Kāfars | | 160,000 |
| 21. Kohistānis | | 100,000 |
| 22. Mixed population and smaller tribes | | 362,000 |
| Total | | 4,900,000 souls. |

There are no made roads in Afghānistān, and scarcely anything is done to facilitate communication. None of the rivers are bridged; and it is only when a road becomes absolutely impassable that it is repaired, and this has to be done by the travellers. There are ferries on some of the rivers, but only where there are no fords.

The two approaches to Afghānistān which were used by the invading forces in 1839 were the Bolān and the Khaibar Passes.

The former leads through Balūch territory to Shālkot (a place generally known to us as Quettah, but not known to the natives by that name), and from Shālkot to Kandahār. The Bolān Pass is entered about three miles from Dādar, and extends for about 56 miles. The distance from Dādar to Shālkot is 86 miles, and from Shālkot to Kandahār 147 miles.* The old descriptions of this pass are very highly coloured, but it is not really so very formidable. As I shall have occasion to mention the chief difficulties of this road when describing the advance of the British force, I will not dwell upon it at present, and will turn to the other route.

The road from Peshāwar to Kābul was used by the native forces under the nominal command of the Shahzāda Taimūr, guided by Lieut.-Col. Wade.

Starting from Peshāwar this road first traverses the Khaibar Pass. Before recent events led to a general study of the geography of Afghānistān, I believe there were not a few people who imagined that 'the

* A sketch of the country from Shālkot to Kalāt and Dādar, for which I am indebted to Captain Pelham Maitland of the Sindh Horse, was exhibited at the lecture.

Khaibar' extended all the way from Peshāwar to Kābul. Many, I am sure, believed that the Khaibar Pass is the place where 'a British army perished' in 1842. Both such beliefs are erroneous. The distance from Peshāwar to Kābul is 193 miles. The Khaibar Pass is entered at 12 miles from Peshāwar, the elevation of which place is 1,068 feet, and four miles from Jamrūd, and extends to a point two miles east of Dakakalān, a distance of 28 miles. Out of this distance there are 22 miles of pass and six miles through the little valley of Lālabeg Garhi. This valley is about $1\frac{1}{4}$ miles in width and is cultivated.

About eight miles from the entrance to the pass is the small fort of Ali Masjid, which was captured by Wade's force, as it has lately been by that of Sir S. Browne. At a mile and a half beyond Ali Masjid, the Lālabeg valley is entered, and after traversing it for six miles there is an ascent over a pass 3,370 feet above the sea, and then a descent two miles long to Landi-khāna, which is 2,490 feet above the sea. From Landi-khāna it is eight miles to the outlet of the pass. Colonel Hough says that this part of the pass is nowhere over 200 yards wide, but the hills, which are precipitous and covered with stunted bushes, are not very high. The descent to Landi-khāna is over beds of loose stones, the road being in fact merely the bed of a torrent. Daka is nine miles beyond Landi-khāna. Close to Daka and the western entrance of the pass lies, on the north bank of the Kābul river, the little town of Lalpūra, the residence of the chief of the Mohmands, who levies tolls on all travellers, and keeps up a bridge of boats between Lalpūra and Daka. The defile, known as the Khurd Khaibar, lies three miles above Daka. It is a narrow ravine, but only about three-quarters of a mile in length, and can be turned by flanking columns. From Lalpūra to Jalālābād, 42 miles, the road lies along the south bank of the Kābul river. Speaking of this part General Nott says: 'It may be described in a general way as a tract of hilly country lying between two ranges of mountains running east and west. It gives (he says) a most erroneous idea of this tract to call it a valley, as it is divided into a series of small plains by cross ranges of hills which descend from the Safed Koh.'

Jalālābād is a small town with a summer population of about 2,000, said to be increased tenfold in winter by the influx of people from the hills. It possesses a delightful winter climate, its elevation above the sea being 1,900 feet only. The plain of Jalālābād is highly cultivated and is 12 or 13 miles long with a breadth of three or four near the town.

South of the vale of the Jalālābād is the district of Nangnahar, which is full of lovely valleys, 'abounding (says Wood) in mulberry, pomegranate, and other fruit trees, while the banks of their streams are edged with a fine healthy sward, enamelled with a profusion of wild flowers and fragrant aromatic herbs.' Near the forts the streams are often fringed 'with rows of weeping willow.'

Unfortunately the neighbouring hills afford but little nourishment for sheep, and the men are mostly robbers in consequence.

From Jalālābād the road again quits the Kābul river, and ascends over a difficult country, skirting the Surkh-āb (red river) to Gandamak, a distance of 36 miles. Gandamak is 4,600 feet above the sea, and lies in a delightful, well-watered valley, planted with fine mulberry trees. It was here that the last survivors of Elphinstone's brigade were killed in January 1842. From Gandamak about 35 miles of difficult road lead to Jagdalak. Just beyond the village of Jagdalak begins the defile of that name, which is about 3½ miles long, and called by the natives the Parī Dara. It is very narrow and stony, and is in fact the gorge through which a stream flows to the north. The average width is 40 to 50 yards, but there are three places where it is less than 10 feet. This place, which can be easily secured by flanking columns, was the scene of a massacre in 1842.

After issuing from the Parī Dara the road winds (still over a difficult country) by Kata-Sangh, Tazīn, and Haft Kotal to the Khurd Kābul Pass. This pass is six miles long and not more than 100 to 200 yards wide. It is (like that of Jagdalak) merely the bed of a torrent, which has to be crossed no less than twenty-three times. It was in this pass, which it entered without any military precautions, that the destruction of Elphinstone's brigade began. Sir George Pollock crowned the heights both in his advance and retreat, and passed it without loss. The northern entrance to the Khurd Kābul is only 10 miles from the city of Kābul. The village of Bût Khāk lies close to the entrance of the pass, and the road from it runs over an open plain, the greater part of which is highly cultivated.

## Political History of Afghānistān.

I must now entreat your patience whilst I take a short survey of the rise of the Dūrāni dynasty and the political affairs of Afghānistān. Prior to the eighteenth century the country belonged at one time to Persia and at another to India, but the plains only were conquered by the Persian and Indian kings; the Afghān tribes remained practically independent. The greatest of the western tribes were the Abdālis, whose original home was in the mountains of Gaur (or Zarni), and the

Ghilzais, who inhabited the country round Kandahār. At the beginning of the eighteenth century the Abdālis chiefly resided in the country round Herāt, but a portion had settled near Nishapur, in western Khōrasān. These two great clans were constantly at feud.

Nādir Shah (a freebooter who rose to power in Persia while his country was suffering from the attacks of the Ghilzais and Abdālis, as well as other enemies) drove the Abdālis out of the province of Khōrasān in about the year 1727.

Ten years later Nādir Shah (who had seized the Persian throne in 1736) laid siege to Kandahār, which was held by the Ghilzais, and skilfully availed himself of old enmities between them and the Abdālis to procure the assistance of the latter. After the fall of Kandahār he removed part of the Ghilzai tribe from their lands near the city and settled Abdālis on them, especially those branches of the clan which he had formerly driven from Nishapur.

Nādir Shah (who sacked Delhi in 1738, and is said to have carried away from that city plunder to the value of 30 millions sterling, including the celebrated peacock throne) retained the throne of Persia till 1747.

In June of that year he was in camp on the frontier of Afghānistān, and there he was murdered by some of his principal officers, who had conspired against him.

Next morning the Afghān chiefs, to whose fidelity he had appealed, attacked the Persian camp, in the hope of rescuing the Shah from the conspirators. The Afghāns were under the command of Ahmad Khān, Abdāli. Finding they had come too late the Afghāns succeeded in effecting their retreat, but not without severe fighting. This Ahmad Khān was the son of Zamān Khān, the chief under whom the Abdāli had first conquered Khōrasān. He was of the family of Saddozai, a branch of the Abdāli tribe which commanded especial veneration. Being already, by birth, at the head of the most powerful of the Afghān tribes, he succeeded (after the death of Nādir Shah) in so rapidly extending his influence, that in October of the same year he was formally declared king at Kandahār. From some superstitious motive he changed the name of his clan from Abdāli to Dūrāni, and by this name it has ever since been known.

Ahmad Shah ruled in Kandahār, Kābul and Herāt, as well as in Balkh, Kashmīr and Sindh. Balūchistān, Sistān, and other provinces, remained under their native chiefs, subject to allegiance and military service.

Scarcely was Ahmad Shah established on the throne when he undertook his first invasion of India. In 1748 he reached Sarhind with 15,000 men. Here he encountered the army of the Moguls, and was beaten, after a contest which lasted nine days. On his retreat northwards he succeeded in forcing the Viceroy of the Panjāb to promise a permanent tribute.

About 1751 he was again in the Panjāb. This time he obtained from his namesake, Ahmad Shah of Delhi, the formal cession of the province.

In 1757 he invaded India for the third time, took Delhi, and repeated the scenes of violence, rapine, and murder which had been witnessed there by the sufferers from Nādir Shah's invasion.

On this occasion Ahmad Shah and his son Taimūr each carried away a princess of the house of Delhi.

Ahmad Shah's fourth and last invasion of India occurred in 1759. He crossed the Indus at Peshāwar in September, and meeting with no opposition in the Panjāb, skirted the hills, in order to avoid the still flooded rivers, and reached the neighbourhood of Sahāranpur, where he crossed the Jamna. The Marhattas had captured Delhi and overturned the Mogul monarchy the year before, and they now opposed him with some 30,000 horse, but were defeated and almost annihilated. Delhi was again taken, and Ahmad Shah remained for some months in Hindustān.

The power of the Marhattas was at this time at its height, and defeat only stimulated them to greater exertions. On hearing of the defeat near Sahāranpur, every effort was made to retrieve it. Sedasheo Bhāo, cousin of the Peshwa, raised a powerful army, and set forth, accompanied by Wiswas Rāo (the young son and heir of the Peshwa), to oppose the Afghāns. They retook Delhi, defaced the tombs, palaces and shrines, and tore down the silver ceiling of the Diwān Khās, which they coined into 17 lakhs of rupees. Whilst all this was happening at Delhi, Ahmad Shah was in cantonments for the rains at Anūpshahar on the Ganges. In October 1760 he passed the Jamna, still partially in flood, and reached Pānīpat, where the Marhattas had entrenched themselves. The force under Sedasheo Bhāo consisted of 85,000 men (70,000 of whom were cavalry) and 200 guns.

Including followers, there are said to have been 300,000 men in the Marhatta camp. The Dūrāni monarch had 88,000 men, but only 30 guns. After some preliminary fighting, Ahmad Shah gained the mastery, and blockaded the Marhattas in their camp, and at last forced them to attack. The decisive battle took place on 6th January 1761, and resulted in the total defeat of the Marhattas. The number of the slain is said to have been nearly 200,000. Both the Bhāo and Wiswas Rāo were killed. Almost all the great Marhatta chiefs were killed or wounded, except those who had been left at Delhi, and Holkar who was accused of too early a flight. Mahājī Sindia (who afterwards founded the present Gwālior State) was lamed for life. The wreck of the Marhatta army retired behind the Narbadda.

Strange to say Ahmad Shah returned home immediately afterwards, and took no more share in the affairs of Hindustān.

In 1762, and again in 1767, he was obliged to enter the Panjāb to chastise the Sikhs, who were becoming powerful. After the campaign of 1767 he was engaged for some time in Khōrasān, and then returned to Kandahār and fell into bad health.

A cancer in the face had afflicted him for some years, and in June 1773 he died of it at Marghā, in the hills of Toba, where he had retired for the summer, at the comparatively early age of 47.

These invasions of India by Ahmad Shah, following that of Nādir Shah, are important to remember, since the terror they created and the prestige they gave to the Afghān power had not (as we shall see) died away when Zamān Shah projected similar schemes nearly half a century later.

Ahmad Shah was succeeded by his son Taimūr, who had been in his youth Governor of the Panjāb. Afterwards he had been made by his father Governor of Herāt. Taimūr was the second son, but was named heir by his father.

His reign of 20 years was not an eventful one. His object seems to have been to secure tranquillity, and in that he succeeded tolerably well. Personally he took the field on two occasions only: once in a campaign to recover Multān from the Sikhs (in 1781), and again in 1789 against the Khān of Bukhāra. His other wars were conducted by Dilāwar Khān, his Commander-in-Chief. He was economical and regulated his finances well. Instead of keeping the Dūrāni troops on foot he maintained order by means of a corps of guards called the Gholām-i-Shah. These being Persians and Tājiks were not likely to join with the Afghān chiefs.

Taimūr transferred the seat of Government from Kandahār to Kābul, apparently with a view to render himself more independent of the Dūrāni chiefs, whose country lies round Kandahār. Kābul being inhabited largely by Persians and Tājiks the population were unlikely to side with the Dūrānis.

Taimūr Shah died at Kābul in May 1793 without having named an heir. He left 36 children, 23 of whom were sons by ten different wives. The most important of these are shown on the table. (*See* Plate III.) Those born of the same mother are bracketed together. Although it is by no means a rule in Afghānistān that sons of the same mother are friends, the converse holds true : the half brothers habitually detest them, and in cases of revolt are nearly always united against them. In taking up arms each family is supported by the mother's tribe.

At the time of their father's death the two elder sons, Humāyūn and Mahmūd were at Kandahār and Herāt respectively. These were the governments with which they had been entrusted by their father. Most of the other sons were at Kābul.

The most powerful of the Sardārs (or nobles) at this time was Payandah Khān, son of Hāji Jamāl Khān, head of the Muhammadzai family and chief of the Bārakzais. He had received from Taimūr Shah the honorary title of Sar-afrās-Khān by which name he is often called.

Payandah Khān gave his adhesion to Zamān, the fifth son of Tamūr, and succeeded in gaining the most influential of the Afghān nobility and the chiefs of the Kazlbāshis at Kābul. He also entrapped the sons of Taimūr and the chiefs of the opposing factions and made prisoners of them all. After they had been kept with nothing but two or three ounces of bread daily for five days, the rival princes consented to acknowledge Zamān as king. They were then imprisoned in the Bāla Hisār or citadel of Kābul. The elder son, Humāyūn, advanced from Kandahār against Zamān Shah, but was defeated and driven into Balūchistān. No sooner did Zamān Shah think himself secure on the throne than he began to meditate an invasion of India. Preliminary to this he endeavoured to concentrate absolute power in his own hands.

He began by taking the great appointments of the State from those who had inherited them as sinecures since the reign of Ahmad Shah. Even Payandah Khān, to whom he owed his throne, was forced to resign the office of Wazīr. Shortly after this the Panjāb was in revolt. Zamān Shah had marched only as far as Peshāwar with intent to chastise the rebels, when he was recalled by the news of his brother Humāyūn being again in arms. After capturing him and putting out his eyes, the Shah set out against the Amīrs of Sindh in order to force them to pay arrears of tribute. He had only reached the Bolān* when news that Mahmūd was now in the field against him forced him again to return. Mahmūd was driven from Herāt and took refuge at Teherān. This was (it seems) early in 1797.

In November 1798 Zamān Shah was at Lahore, and there received the homage of all the chiefs, both Sikh and Musalmān, including that of Ranjit Singh, now Rāja of the Sikhs.

After the removal of Payandah Khān from the office of Wazīr,

* Ferrier; but Elphinstone says he was at Lahore.

Zamān Shah had made Waffadār Khān, a Popalzai, the Wazīr. Acting on Waffadār Khān's advice a number of harsh measures were taken against the great families of the country, the policy being probably to reduce the power of the barons. This policy naturally excited wide-spread discontent, and led to a conspiracy to overthrow Zamān, and to place Shūja-ul-Mulkh on the throne. Articles were drawn up by the chiefs forming a sort of constitution, one of the clauses making the crown elective.

The plans of the conspirators were betrayed, and they were all seized and brought before the Shah. On being questioned they avowed their intentions to dethrone him, in consequence of their conviction that it was hopeless to induce him to dismiss the Wazīr, but they protested that they had had no intention of putting him to death. The king, however, after hearing their avowal, ordered them all to be executed in his presence, including Payandah Khān, and their bodies exposed on the public square for three days. It was this act of Zamān Shah's which not only cost him his own throne, but led directly to the downfall of the Saddozai dynasty.

Payandah Khān left 21 sons to avenge his fall, the eldest of whom (now chief of the great clan Bārakzai) fled to Persia, where he joined Prince Mahmūd. Mahmūd had received help from the Persian monarch (Fatah Ali Shah), and being joined by the greater part of the Bārakzai brothers, and assured of a good reception from the Dūrāni tribes (who were disgusted by the cruelties of Shah Zamān), now regained possession of Kandahār, from which place he moved on Kābul.

Zamān Shah, deserted by nearly all his supporters, had to evacuate the capital. On leaving it he was accompanied by two chiefs only, one being the Wazir Waffadār Khān, and escorted by only 600 men. Shortly after Zamān Shah was betrayed by a khān, in whose fort he had taken refuge, near Jagdalak. By order of his brother his eyes were put out; while Waffadār Khān met the death he richly deserved.

This happened in the year 1800. Mahmūd did not long enjoy the throne. He was a weak, helpless creature, and owed his short-lived success to the promptings and support of Fatah Khān Bārakzai. He was hardly seated on the throne before the Ghilzais rebelled, and soon after they had been reduced to submission by Fatah Khān, disturbances took place at Kābul between the Afghāns and the Kazlbāshis. Two years later, when Fatah Khān was absent from Kābul on an expedition against the Hazāras, Shah Mahmūd was dethroned by a conspiracy, of which Shīr Muhammad Khān (Mukhtar-u-Daulat) was one of the chiefs, and his brother Shūja-ul-Mulkh put on the throne in his place.

This was in July 1803. Shūja-ul-Mulkh would have followed the usual Afghān custom in like cases and blinded his brother, but Mahmūd's eyes were spared at the intercession of Shīr Muhammad Khān. Shūja-ul-Mulkh, as we shall see, was not long in finding out that his clemency was misplaced. Mahmūd was, however, imprisoned in the Bāla Hisār. Fatah Khān on his return from Bamiān joined the new king, and they went together on an expedition against the Amīrs of Sindh, who owed £320,000 (32 lakhs of rupees) arrears of tribute. But Shūja-ul-Mulkh's great object, like that of Zamān, seems to have been to make himself independent of the barons. He soon disgraced Fatah Khān, and deprived the Muhammadzais of their appointments. Sardār Akram Khān was made Wazīr in the place of Shīr Muhammad Khān.

At the accession of Shah Shūja he at first held Kābul only, whilst Kandahār was in the possession of Kamrān, son of Mahmūd, and Herāt belonged to Hāji Fīroz-u-Dīn. One of his first acts was to send his nephew, Kaisar, to turn Kamrān out of Kandahār, an undertaking which was for a while successful. It would be useless to follow all the ups and downs of fortune. Suffice it to say that after a while Mahmūd escaped from prison through the aid of Fatah Khān, and a battle between Mahmūd and Shah Shūja took place at Nīmla, near Gandamak, in which Shah Shūja was defeated and forced to fly, leaving all his baggage, £2,000,000 sterling, and precious stones to a large amount, on the field. Shūja-ul-Mulkh made his way towards Kandahār to join his nephew Kaisar, but both were defeated by Pūrdil Khān, one of Fatah Khān's brothers. This was in June 1809.

When Shah Shūja fled from the field of Nīmla he carried with him the celebrated Koh-i-nūr (or Mountain of Light). This precious stone was the cause of many sufferings which he had to endure. He was first seized and imprisoned by Atta Muhammad, Governor of Kashmīr, who sought by threats of violence to force him to give it up. He was released from captivity in Kashmīr only to fall into the hands of Ranjīt Singh. Shūja-ul-Mulkh had not been two days in Lahore before Ranjīt formally demanded the surrender of the diamond. After a month or so passed in negotiations, Ranjīt Singh finally obtained it in return for some grants of land. It remained at Lahore until that place was captured by the British in 1849, when the great diamond became one of the English crown jewels.

Mahmūd, re-seated on the throne, after the defeat of Shah Shūja at Nīmla, gave himself up to all sorts of debauchery, leaving to Fatah Khān the task of government. Fatah Khān, ably supported by his many brothers, made his name famous in Central Asia, and brought the country to something like the commanding position it held under Ahmad Shah. Herāt, indeed, was left to Fīroz-u-Dīn, but the Amīrs of Sindh and Balūchistān were forced to return to their allegiance. The Hazāras also were reduced to obedience, and, generally, security reigned throughout the kingdom. Fatah Khān placed some of his brothers in command at Kandahār, Ghaznī, Bamiān, Peshāwar, and other places, while he retained four of them, including Jabbar Khān and Dost Muhammad, near his own person to assist in administration.

In 1816 the Shah of Persia (Fatah Ali Shah) marched an army against Herāt. Hāji Fīroz-u-Dīn (very reluctantly) applied to his brother, Mahmūd, of whom he had hitherto been independent, for aid.

Mahmūd, as usual, sent Fatah Khān to do the fighting for him. The Persians were defeated, but Fīroz-u-Dīn was (as he had feared) none the better for his brother's intervention, for Fatah Khān deprived him of his power, and sent him a prisoner to Kābul.

When Hāji Fīroz-u-Dīn arrived at Kābul, the prince Kamrān, who had long been at enmity with Fatah Khān, represented to his uncle, Mahmūd, that Fatah Khān had insulted the royal dignity by sending the Hāji as a prisoner. Moreover, Dost Muhammad had been guilty of pillaging the harem of Fīroz-u-Dīn, and had even stripped the princesses of their clothes, and this had been done with the cognisance of Fatah Khān. The complaints of Fīroz-u-Dīn, backed by Kamrān, and by others who were jealous of Fatah Khān, induced Mahmūd Shah to give an order that the eyes of Fatah Khān should be put out. Kamrān, overjoyed at the prospect of being revenged on the Bārakzai, kept his order secret, and started at once for Herāt to execute it. He was well received by Fatah Khān, and soon found an opportunity to arrest his victim when slightly escorted, and had his eyes immediately put out. He hoped to have secured the brothers Pūrdil Khān, Shīrdil Khān, and Kohandil Khān, who were also at Herāt, but they escaped, except Pūrdil Khān, who was thrown into prison. Pūrdil Khān soon after escaped, whereupon Kamrān revenged himself by torturing the unfortunate Fatah Khān, burning his eyes, in which a ray of light still remained, with a hot iron.

This was about 1818. When the news of the cruelties inflicted on Fatah Khān reached his brother Muhammad Azīm, who was then Governor of Kashmīr, he soon raised the standard of revolt. It happened that Dost Muhammad was then in prison in Kashmīr. He had fled from Herāt rather than comply with his brother's orders to surrender the spoil of Hāji Fīroz-u-Dīn's harem, and coming to Kashmīr had been arrested there. Now, however, he took up arms to avenge his brother's sufferings and advanced to Kābul, supported by Muhammad Azīm.

By this combination Mahmūd Shah was driven from Kābul, and, as we shall see, the Saddozais have never recovered the place for themselves, though some of them have since reigned there as the creatures of others.

Flying from Kābul, Mahmūd met at Ghaznī his nephew Kamrān, with troops from Kandahār. Together they moved towards Kābul, but their troops deserted to Muhammad Azīm. Mahmūd and Kamrān then fled towards Kandahār taking Fatah Khān with them. Mahmūd endeavoured to make him write to his brothers and desire them to return to their allegiance, but in vain. Kaye thus describes the closing scene:—

> Exasperated by the resolute bearing of his prisoner, Mahmūd Shah ordered the unfortunate minister—the king-maker, to whom he owed his crown—to be put to death before him; and there, in the presence of the feeble father and the cruel son, Fatah Khān was literally hacked to pieces. His nose, ears, and lips were cut off; his fingers severed from his hands, his hands from his arms, and his arms from his body. Limb followed limb, and long was the horrid butchery continued before the life of the victim was extinct. Fatah Khān raised no cry, offered no prayer for mercy. He died as he had lived, the bravest and most resolute of men—like his noble father, a victim to the perfidy and ingratitude of princes. The murder of Payandah Khān by Zamān Shah shook the Saddozai dynasty to its base. The assassination of Fatah Khān by Mahmūd soon made it a heap of ruins.

Mahmūd retired on Kandahār, but, finding that it had fallen into the hands of Pūrdil Khān, avoided it, and reached Herāt with great difficulty by traversing the country of the Hazāras.

From this time till his death in 1829, Mahmūd was, with the exception of a short space when he was driven away by his son Kamrān, the ruler of Herāt. At his death Kamrān succeeded to the principality, and retained it till he was murdered in March 1842 by his Wazīr, Yar Muhammad. On the flight of Mahmūd to Herāt, Pūrdil Khān and Muhammad Azīm (see tabular statement of the Bārakzais) remained masters of Kandahār and Kābul respectively. Neither felt himself strong enough to stand alone, and a Saddozai was wanted in whose name the Government should be carried on. Overtures were therefore made to Shah Shūja, who proceeded to Afghānistān, but, being too exacting, had scarcely arrived there before he fell out with his Bārakzai supporters and had to take refuge in Sindh.

Shortly after, another puppet was formed in the person of Ayūb, one of the other sons of Taimūr Shah, but did not long retain the semblance of power. About 1820 the country of Afghānistān was parcelled out amongst the Muhammadzai Sardārs in this wise:—

Kābul was held by Muhammad Azīm; Ghaznī by Dost Muhammad; Pūrdil Khān, Kohandil Khān, and their three brothers had Kandahār; Jabbar Khān held the Ghilzai country; and Sultān Muhammad and his brothers held Peshāwar.

In 1823 Muhammad Azīm Khān died, whereupon a war broke out between the Muhammadzai brothers, Sultān Muhammad and Dost Muhammad siding together against the Kandahār Sardārs. This was put an end to by the generosity of Pūrdil Khān, who, after defeating Sultān Muhammad and the Dost, withdrew his claims and retired to Kandahār, having first persuaded the brothers to take an oath that nothing should disunite them for the future. Sultān Muhammad was to have Kābul and Dost Muhammad, Ghaznī.

Soon after this, however, Sultān Muhammad and Dost Muhammad fell out again, in consequence of a love affair, and a merciless war was carried on between them for two years, which ended in 1826 by Dost Muhammad establishing his authority at Kābul. From this time to the day when his followers deserted him at Argandi, thirteen years later, Dost Muhammad was supreme at Kābul. He was in alliance with his brothers the Sardārs of Kandahār, but continued at enmity with Sultān Muhammad at Peshāwar.

In 1832 Dost Muhammad and his brothers had to fight for their possessions against Shah Shūja, who, according to Ferrier, had already made no less than eight attempts to recover the throne. He had now collected an army, and, after defeating the Tālpūra Amīrs* at Rohri, advanced to Kandahār at the head of 22,000 men, and laid siege to it. But he was defeated under the walls of the city, and fled, escorted by only 50 horsemen. Meanwhile, Ranjīt Singh took advantage of the opportunity to drive Sultān Muhammad from Peshāwar and take possession of that place and district.

Dost Muhammad, on his return from Kandahār to Kābul, assumed the title of Amīr-ul-Mūminīn, and shortly after proclaimed a religious war against the Sikhs and proceeded to Peshāwar with a large army. Ranjīt Singh, in dismay, had recourse to corruption. Sultān Muhammad was induced to withdraw with 10,000 men, and the Amīr's army soon melted away. This seems to have been in 1834.

I have now, at what I fear may be thought a wearisome length, traced the course of Afghān domestic politics up to the time when the interventions of the British took place. It is now necessary to look at the events external to Afghānistān itself, which, though the country had lost its offensive power, led the Indian Government to take much interest in its affairs. In doing this it will be unavoidable to glance at Persian politics.

At the beginning of the present century what the Government of Calcutta dreaded was an actual invasion of India by the Afghāns. The prestige created by Ahmad Shah's invasions had not then died away, and the news of Zamān Shah's preparations alarmed even such a man as the Marquess Wellesley.

* The Amīrs of Sindh.

With the decline of the Dûrâni empire the fear of an Afghān invasion ceased to operate, and other causes began to affect our policy. In 1805 the Shah of Persia, alarmed at the advance of Russia in the Caucasus, applied to the Emperor Napoleon for help. A French agent soon arrived at Teherān. A little later (in 1807) the French Emperor and the Russian, in alliance, were projecting a joint invasion of India. This led to negotiations between the Governor-General and the Shah. In 1809 a treaty was made between the Shah of Persia and the Indian Government, one of the chief points of which was that 'no European force should pass through Persia either towards India or any of the ports of that country;' and in 1812 a definitive treaty (to which that of 1809 was preliminary) was signed. One of the stipulations of this treaty was that England should provide officers, men, &c., for a Persian flotilla on the Caspian.

The treaty of 1812 was not finally completed till October 1814, and in the meanwhile Russia had concluded with Persia the treaty of Gūlistān. By this last-named treaty Persia had given up the right to maintain a naval force on the Caspian, and therefore the clause relating to the flotilla had to be expunged from the final treaty.

Under the treaty of 1809 English officers had been employed in drilling the Persian troops, and they achieved some successes against the Russians in the war which had been going on for some years. They were necessarily withdrawn when England and Russia became reconciled in 1812, and in 1813 peace was made between Persia and Russia.

From 1813 to 1826 there was no open outbreak between Russia and Persia. In that year began a war, most disastrous to Persia, which was brought to a close by the treaty of Turkomānchai in February 1828.

Under this treaty the provinces of Erivan and Nakhichevan were ceded to Russia, and the sole right of having armed vessels on the Caspian was again formally conveyed to her.

Russian influence having become by this treaty predominant at Teherān, the attention of Indian statesmen was again turned to Afghānistān.

But Russia was continually encouraging the Persians to aggression to the eastward, and in 1831 the Prince Royal (Muhammad) of Persia determined on an expedition to Khōrasān.

In 1833 he was arrested, while on his march towards Herāt, by the news of his father's death; but it remained a favourite project, and at last, in October 1837, the Persian army actually entered the province of Herāt, and on the 23rd of November laid siege to the city.

The siege of Herāt, a place which has often been called the key to India, and which holds a very high importance in Asian politics, was very differently regarded by the various potentates whose conduct we are following.

(1) The Bārakzai Sardārs of Kandahār (brothers, be it remembered, of Dost Muhammad) had never forgotten that Shah Kamrān, the ruler of Herāt, was the murderer of their brother Fatah Khān. They were delighted at the prospect of his overthrow, and hoped, as tributaries of the Persians, to obtain the principality.

(2) Dost Muhammad, on the contrary, looked with alarm on the Persian advance, backed as it was by Russia. Sir Alexander Burnes was then on a mission to Kābul, with a view, primarily, or at least ostensibly, to the opening up of the trade of the Indus. The Amīr applied to Burnes for advice, and promises of assistance and support, but all in vain: Sir Alexander Burnes could give him none.

(3) In India the point of view from which a siege of Herāt was regarded had greatly shifted since the beginning of the century. Whereas in 1800 the immediate object of the mission to Persia, under Captain Malcolm, had been to push a Persian army on Herāt, with a view to diverting Shah Zamān from his long-threatened invasion of Hindustān, the Governor-General was now greatly alarmed at the prospect of the place falling into Perso-Russian hands.

Burnes had arrived at Kābul on September 20, 1837, just two months before the siege begun. Only a few days after him arrived Captain Vikowitch, a Russian agent, sent by General Simowitch, the Russian minister at Teherān. Vikowitch was at first not well received by Dost Muhammad, who much preferred the British alliance, and hoped through it to obtain a settlement of his disputes with Ranjit Singh.

The policy of Lord Auckland (then Governor-General of India) is difficult to understand. Though Dost Muhammad was most anxious for his alliance, Lord Auckland seemed afraid to do anything for him, while he eventually undertook a far more difficult and costly scheme. Ultimately, no doubt, the promises of the Russians, coupled with the reserve imposed on Burnes, encouraged the Dost to insist on the retrocession of Peshāwar as the price of his alliance—a proposal which the relations of the Indian Government with Ranjit Singh rendered inadmissible. On April 26 Sir A. Burnes left Kābul, and the rupture between the British and the Amīr was complete.

Meanwhile, the siege of Herāt went on. Yar Muhammad, the Wazīr of Kamrān, made a brave defence, directed and urged on by Lieutenant Eldred Pottinger, of the Bombay artillery.

Herât is defended by earthworks of enormous size traced on an irregular quadrangle, the north and south sides being about three miles in length, the others somewhat more.

The rampart is of earth about 90 feet in height, and revetted inside with masonry. On the summit of the rampart (which Ferrier describes as resembling a long hill when seen from outside) is a wall 32 feet high flanked with round towers loopholed for musketry.

The attack was made entirely without plan, the Shah ordering each of his lieutenants to take up any point he thought eligible, without concert, as each would then derive from his own deeds the honour due to them. All this time the Shah had in his service a scientific officer, Colonel Semineau, a Sardinian who had served in the French engineers under Napoleon, but he was unable, owing to intrigues against him, to do more than submit to the Shah a project of siege, which was not attended to.

About April of 1838 General Simowitch arrived in the Shah's camp and took an active part in the siege. By his order, Lieut.-Col. Blaremberg, the Russian officer of Engineers attached to the mission, inspected the works; he approved of Semineau's plan, and it was put in operation, General Simowitch actually paying the men employed in making fascines and gabions.

On the 24th June the assault was delivered, but it failed, partly owing to the energy of Eldred Pottinger and the bravery of Dīn Muhammad, who commanded the Afghān reserve force, partly through treachery. Ferrier tells us that the storming column, consisting of 400 men (Kāragūzlu), had only seven rounds per man allowed to them, and that 'the gold of England,' and the orders of one Hāji Mirza Agāsi, prevented their receiving any support from the rest of the troops.

In India the moral effect of the siege of Herāt was great. Kaye tells us that not only did some of the neighbouring states become restless and threatening, but even in our own provinces there was an uneasy, restless feeling among all classes. Among our Musalmān subjects the feeling was somewhat akin to that which had unsettled their minds, when the rumoured advent of Zamān Shah made them look for the speedy restoration of Muhammadan supremacy in Hindustān. The Muhammadan journals teemed with the utterances of undisguised sedition. There was a decline in the value of public securities; and it went openly from mouth to mouth, in the streets and bazars, that the Company's Rāj was nearly at an end.

The siege of Herāt found the Governor-General without any definite policy. Early in 1837, Mr. McNeill recommended the consolidation of the whole of Afghānistān under Dost Muhammad, with a view of forming a bulwark between Persia and Hindustān. Sir Claude Wade (then Captain Wade), who was the Governor-General's agent on the north-west frontier, opposed this view. He desired to strengthen the then existing governments of Afghānistān, and induce them to act together for the defence of their country. When Burnes was sent to Kābul in September, the Indian Government appear to have hoped that offers of trifling assistance, or mere sympathy and the approbation of the Governor-General, would suffice to induce the Amīr to resist the Persians.

Under the circumstances it ought not to have surprised any one that Sir A. Burnes should have to quit Kābul without effecting anything. But apparently this result *was* unexpected, as no alternative policy had been decided on. Burnes left Kābul in April, yet in May Lord Auckland was still writing minutes in which three widely different courses are discussed. The third of these contained the beginnings of the policy subsequently adopted. It was, 'to permit or to encourage the advance of Ranjit Singh's armies upon Kābul under counsel and restriction, and, as subsidiary to his advance, to organise an expedition headed by Shah Shūja. In this expedition a British agent was to accompany the Shah, and the British Government to supply money and officers to direct the Shah's troops.'

At the beginning of June 1838, Mr. Macnaghten opened negotiations with Ranjit Singh, and on the 26th of that month what is known as the Tripartite Treaty, between Ranjit Singh and Shūja-ul-Mulkh, 'with the approbation of' the British Government, was signed.

According to this treaty the Sikh Rāja was to advance on Kābul from Peshāwar, while Shah Shūja himself should operate from Shikārpur, with the countenance and pecuniary assistance of the British Government. It was, no doubt, soon perceived that the expedition as thus arranged was not likely to be successful. Ranjit Singh was only lukewarm, while the Sikhs were detested in Afghānistān, and the result of the previous attempts made by Shah Shūja to recover his throne did not promise much success for a new one.

The result was that by degrees the views of the Governor-General expanded until at the beginning of the month of August it had been decided to employ a large British force.

No doubt the importance of raising the siege of Herāt weighed in the counsels of the Governor-General. However the collective action of the various chiefs of Afghānistān might be combined for the defence of their country against an advance of the Persians, it could scarcely be hoped that any offensive action towards Herāt would be achieved, and that, as we shall see, became part of the plan of the Governor-General.

In August (1838) the various regiments selected by the Commander-in-Chief were warned for active service, and on the 13th September a general order was published detailing the force and appointing a rendezvous at Karnāl.

On the 1st October * appeared the so-called 'Simla Manifesto,' in which the Governor-General set forth (with a not too scrupulous regard for truth) the reasons for his action. The conduct of Dost Muhammad was misrepresented, all mention of his anxiety for a British alliance being carefully suppressed.

The siege of Herāt was referred to, and a hope expressed that the besieged might hold out until succours from British India should reach them. The declaration went on to say that pressing necessity warranted us in espousing the cause of Shah Shūja-ul-Mulkh, whose popularity had been proved to his lordship, and that H.H. the Mahārāja Ranjīt Singh had bound himself to co-operate for the restoration of the Shah.

It added that the Governor-General confidently hoped that the Shah would be speedily replaced on his throne by his own subjects and adherents; and when once he should be secured in power, and the independence and integrity of Afghānistān established, the British army would be withdrawn.

Whilst this manifesto was being prepared, the chief danger with which India was threatened was passing away. In September, the siege of Herāt was raised. Almost simultaneously with the assault of Herāt, in June, a small British expedition had moved up the Persian Gulf, and on the 19th had landed a small force at Karrak. Report magnified the dimensions of the force so much, that when Colonel Stoddart arrived in the Persian camp in August, charged by Mr. McNeill to demand the withdrawal of the army, he found the Shah inclined to comply. On the 9th September the Shah abandoned the siege and marched for Teherān. In those days it took a considerable time for news to reach India from Herāt, and meanwhile, the preparations for the campaign went on.

* Perhaps, in these days of telegrams, it is as well to observe that nothing could be known at Simla on the 1st October of what had happened at Herāt in the month of September.

## Campaign of 1838-9

The conditions under which the invasion of Afghānistān was undertaken in 1838 are so different from those which exist at the present time, that it is important to clearly realise what they were.

First of all, the Panjāb was independent, and though we were in alliance with Ranjīt Singh, *he* was not anxious to see too much of his allies, and *we* were not too confident of his fidelity. Even had he been willing to throw open the road through his territories for the passage of a British army, it was a difficult line of advance for a large force. No Grand Trunk Road then existed from Lūdiāna to Peshāwar, and the passage of six rivers (not in those days provided for by well-constructed floating bridges as at present) would have greatly added to the difficulties of the march.

Instead, therefore, of taking the direct line of Lahore and the Khaibar Pass, the Bengal force had to make a great detour through the protected states to gain the Indus at Sakkar, to advance through the Bolān to Kandahār, and thence march by Ghaznī to Kābul. From Karnāl, which was in those days the most advanced of our great military stations (Lūdiāna and Fīrozpūr being what may be termed outposts), there are 42 marches (about 470 miles) to Peshāwar, from whence Kābul is distant 20 marches, 193 miles. Total distance on the direct line from Karnāl to Kābul, 62 marches, or 663 miles.

The route actually followed, instead of this direct line, made the distance no less than 1,385 miles, and increased the number of marches to 132.

But, again, the road chosen was far from offering the facilities which it would do at the present day, even were steam boats and railways still things of the future. Instead of the Bombay Presidency extending, as it now does, 400 miles up the Indus, and nearly 100 miles above Sakkar, it was bounded on the north by the Rann of Kachh, Dīsa being its frontier station. The Bombay force was to begin by taking possession of Karāchi, and had to make 39 marches (covering 476 miles) before effecting a junction with the Bengal column at Dādar. This march lay up the right bank of the Indus, through a population more or less hostile, and was not accomplished without loss. On the west, the line of march was flanked by the Balūchistān frontier, the ruler of which, Mahrāb Khān, though nominally friendly, was ill-disposed, whilst the eastern bank of the Indus belonged to the Amīrs of Sindh, then a state quite independent of the British, and one which it required all the efforts of diplomacy, backed, as we shall presently see, by a considerable display of force, to keep from open hostility.

The three principal Amīrs of Sindh could bring about 12,000 men into the field, besides some Balūch mercenaries.

Arrived in Afghānistān, the opposition to be encountered was estimated as follows :—

1st. The rulers of Kandahār, who were believed to dispose of 4,000 to 5,000 men, but it was doubted whether they had any artillery.

2nd. The regular army of the Amīr, 15,000 men, chiefly horse. Besides guns for the defence of fortresses he was said to possess a respectable field artillery.

3rd. Attacks from predatory tribes.

4th. At Herāt, we might have to encounter 50,000 Persians, who had a moveable artillery as well as a siege train.

Further than this, it was not known that the reserve of the Persian army might not consist of some of the Czar's legions under Paskievitch, the conqueror of Erivan.

The force with which it was proposed to overcome all this opposition, actual and possible, seems small indeed; it consisted of about 20,000 British troops from Bengal and Bombay, with 6,000 of Shah Shūja's contingent, all destined to act in Sindh and Afghānistān, while a little over 10,000 natives, partly belonging to Shahzāda Taimūr, and the rest Sikhs, were to operate from Peshāwar. In addition, Ranjit Singh was to form an army of observation of 15,000 men on his north-western frontier. (*See* Appendix I.)

In criticising the composition of the force, we have to remember that the Governor-General had been led to believe that the Afghāns would be glad to get rid of Dost Muhammad, and to see Shah Shūja established in his place, and that, consequently, very little opposition was to be anticipated. The event indeed justified this expectation as regards the absence of any serious opposition, but the despatch of a force of 4,000 or 5,000 men (such as Hough tells us was to have been sent from Kandahār to Herāt) would have made a serious difference. Even when the scope of the operations was modified by the raising of the siege of Herāt, we shall find that the want of troops to guard the communications soon made itself very seriously felt.

A summary of the troops available before the reduction of the force is given in Appendix I.

The Bengal force consisted of a brigade of cavalry, formed of the 16th Lancers and three native regiments, under Colonel Arnold of the 16th, as Brigadier; an artillery brigade of three batteries under Brigadier Graham, and five brigades of infantry. The first Infantry Brigade, consisting of the 13th Light Infantry and two N.I. battalions, was commanded by Colonel Sale of the 12th; the second, containing three N.I. battalions, was under Major-General Nott; the third, formed by the 3rd Buffs and two N.I. battalions, was headed by Colonel Denniss, of the Buffs; while the fourth, comprising the 1st European (now the 101st) with two native battalions, was under the orders of Lieut.-Col. Roberts of the 1st Europeans; and the fifth, under Brigadier Worsley, had, like the second, three N.I. battalions.

The Bombay column consisted of a cavalry brigade, an artillery brigade, and two brigades of infantry. The first was composed of two squadrons only of the 4th Light Dragoons (now 4th Hussars) and 1st Bombay Light Cavalry. Besides, there were the Pūnah Horse, but they did not belong to the brigade. The artillery were two troops of Horse Artillery and one field battery. The first Infantry Brigade had the 2nd Queen's, the 17th Regiment, and 19th N.I.; the second consisted of three native battalions. The infantry was commanded by Major-General Willshire, C.B.; Major-General Thackwell commanded the cavalry.

The Bombay column was sent by sea to Karāchi, and was expected to obtain transport from Sindh, and then to march up the Indus and form a junction with the Bengal force at Sakkar. Lieut.-General Sir John Keane, Commander-in-Chief in Bombay, commanded this column. Sir Henry Fane had previously sent in his resignation of the command in India, but withdrew it at the request of Lord Auckland, and was to assume the command of the whole force. Meanwhile he was to command the Bengal column, having Major-General Sir Willoughby Cotton and Major-General Duncan as generals of division. It was intended to put Major-General Thackwell in command of the combined cavalry, when the two columns were united, and Brigadier Graham (who had distinguished himself in the Burmese war) in command of the combined artillery.

The regiments selected had been already warned in August, and those of the Bengal column were to rendezvous at Karnāl at the end of October, ready to continue their march by brigades early in November. This, in those days before railways, necessitated many a long march in the rainy season from 'down country' stations, some battalions having to come from as low down as Banāras. All struggled eagerly on, and by the appointed time were assembled at Karnāl. The bulk of the Bengal force marched from thence on the 8th and 9th November, the 1st, 2nd, and 3rd Brigades of Infantry taking the road by Kaithal, the 4th and 5th by Malair Kothla, a place which in 1872 became known to many as the scene of the Khūka outbreak. By the 29th November the whole of the force was assembled in camp, west and north-west of the town of Firozpūr, where also was the camp of the Governor-General, who had come to have an interview with the

Mahārāja Ranjīt Singh. On the 29th November 1838 the meeting between Lord Auckland and the Mahārāja took place.

But before the troops had marched from Karnāl, news which seriously affected the destination of the army had reached the Government. By the 22nd October it was known to the Government of India that the Shah of Persia had, in compliance with the demands of Her Majesty's Government, raised the siege of Herāt, and had retreated into his own country. One would have thought that there would now be an end of the expedition, but the Governor-General determined 'to prosecute with vigour the measures which had been announced with a view to the substitution of a friendly for a hostile power in the eastern provinces of Afghānistān.' In other words, it was determined to persist in deposing Dost Muhammad and placing Shah Shūja in his stead on the throne of Kābul. This modified plan did not require so large a force as the original programme. On the 27th November the Commander-in-Chief issued a general order announcing that a part of the force assembled would be equal to the objects now in view.

In consequence, the 3rd and 5th brigades of infantry were ordered to remain in observation on the line of the Satlaj; the irregular cavalry under Colonel Skinner (Skinner's Horse is now the 1st Bengal Cavalry) were to remain also, and the artillery force was reduced, Brigadier Graham giving up the command to Major Pew. Moreover, Sir Henry Fane, now that the force was so much reduced and its scope curtailed, gave up the chief command, and Sir John Keane was nominated as the new chief of what was left, which retained the somewhat theatrical designation of 'The Army of the Indus.'

After some days spent in ceremonial at Fīrozpūr, the Bengal column, now reduced to about 9,500 men, marched for Bhāwalpūr. The distance from Fīrozpūr to Bhāwalpūr is 230 miles, and is divided into 18 marches, which are therefore nearly 13 miles each. This force of 9,500 men was attended by 38,000 camp followers, and required for its transport no less than 30,000 camels. The Head-quarters, with the Horse Artillery and Cavalry, the three brigades of Infantry, the Artillery, the Commissariat stores and supplies, marched in separate columns on three successive days. The Commissariat carried 30 days' supplies of all kinds, while slaughter cattle for two and a half months accompanied the force. Additional grain, as well as the sick and the hospital stores went down by water, since the line of march never deviated more than 20 miles from, and generally was quite close to, the river Satlaj.

The baggage of the army was enormous. No stringent orders appear to have been issued, though Sir Henry Fane had issued an order *cautioning* all against large tents or establishments. This caution does not seem to have been attended to, for Lieut.-Col. Hough says, 'most of the officers had too many camels, too large tents, and too much baggage.' Sir G. Lawrence says that 'one officer (of 16th Lancers) had as many as *forty* servants.'

Notwithstanding that the road, which had been repaired by Lieutenant Makesen, was good, and provisions and forage of all kinds, owing to the goodwill of Bhāwal Khān (the chief of Bhāwalpūr) were plentiful, the hired camelmen deserted in large numbers, taking their camels with them. They were appalled at the prospect of leaving their own country, and, moreover, the camels suffered from feeding on the Tamarisk jungle (or jhā-o) which overspread the plains.

Bhāwalpūr was reached in 18 marches, on the 29th December 1838.

On the 1st January 1839 the Bengal force resumed its march, and on the 14th entered the territory of the Amīr of Sindh near Sabzalkot. On the 13th Sir Alexander Burnes, who had been deputed to arrange the cession of Bakkar with Mīr Rūstam, the Amīr of Khirpūr, joined the Head-quarters' camp. On the 24th January the Head-quarters reached Rohrī, the distance from Bhāwalpūr being 225 miles, or 20 marches.

Whilst these movements of the Bengal column had been going on, Sir John Keane, with the Bombay force, landed in the last week of November at Vikkar on the Indus, about 50 miles east of Karāchi. After some delay he moved up the Indus to Tatta, but was for some time unable to advance further for want of transport. The Bombay Government had relied on the friendship of the Amīrs of Haidarābād, but as these Amīrs were, under the terms of the Tripartite Treaty, to be mulcted to the tune of 25 lakhs of rupees (arrears of tribute due to Shah Shūja), their feelings were not so friendly as might have been wished. Fortunately, Sir John Keane was able to obtain a small supply of camels from the Rāo of Kachh, and then, on December 24th, commenced his march into Sindh.

The Amīrs of Haidarābād held two releases from the Shah Shūja for the arrears of tribute, and they not unnaturally demurred to paying the demand. They assembled a force chiefly of Balūchis, said to amount to 25,000 men, for the defence of their capital. On the 26th January, Sir J. Keane was at Jarrak, on the right bank of the Indus (only two marches from Haidarābād, which is on the left bank), but so defective was the communication between the two columns that this fact was not known at the Bengal Head-quarters till 5th February, when Sir Willoughby Cotton was on the march for Haidarābād. In the temper in which the Amīrs were found, it would obviously have been a great military error to advance without reducing them to submission.

Sir Henry Fane, therefore, in spite of the protests of the Envoy, determined to move a part of the Bengal force to co-operate with Sir John Keane in subduing the Amīrs. This is one of the first of a long series of misunderstandings between the military chiefs and the 'Politicals' (as they are called in India), which led to so much disaster in Afghānistān. It may be as well to explain what is meant by Politicals. The word is used in India not in the sense in which we use it at home, but rather as an equivalent for diplomatic. The residents at such Courts as Gwālior, or Indūr, are called political agents, and, generally, all officers whose duties are to conduct the relations of the Government with independent states, either within or without the frontiers of India, are so called. Many of these were young officers, able and energetic in their way and generally good linguists, but necessarily without experience in war, yet they were often in a position to dictate to officers of great experience the course they should pursue. One of the first acts of Lord Ellenborough, on succeeding Lord Auckland, was to place the political power beyond the frontier in the hands of the general officers.

Sir Willoughby Cotton marched from Rohrī for Haidarābād on the 30th January 1839, with a strong brigade of all arms, consisting of 3 battalions, 10 squadrons, and 12 guns of Horse Artillery. No siege guns were taken, which was certainly a serious omission. The total force was about 5,600 men. Sir Willoughby's order of march was as follows :—

1. 1 squadron Cavalry.
2. H.M.'s 13th Light Infantry.
3. 2 batteries Horse Artillery.
4. 3 squadrons.
5. 1 battalion Native Infantry.
6. 2 regiments Native Cavalry.
7. The baggage.
8. 1 battalion Native Infantry.

The Amīrs, alarmed at the forces which were moving towards their capital, submitted and agreed to the terms forced upon them, and on 6th February, Sir Willoughby Cotton, who had covered seven out of the fourteen marches between Rohrī and Haidarābād, was recalled, and on the 15th regained the camp at Sakkar. Sir John Keane continued his march up the right bank of the Indus by Larkāna for Gandāva.

Before the movement of the column under Sir Willoughby Cotton towards Haidarābād the passage of the Indus had been secured by the occupation of Bakkar and Sakkar. I have already mentioned that the temporary cession of these important places had been arranged by Sir Alexander Burnes with Rūstam Khān, of Khīrpūr. It was not, however, till the 29th January that the fort was actually taken possession of by the British.

The fort of Bakkar stands on a rocky island in the middle of the stream of the Indus. Rohrī is the town on the left and Sakkar that on the right bank. The islet on which stands the fort of Bakkar is described by Havelock as being 800 yards in length and from 100 to 150 in breadth. The whole was covered by the enceinte and buildings of the fort, which reached down to the water's edge. The elevation of the island above the river is 25 feet; walls 30 to 35 feet high. It is commanded from Rohrī. At the time of the passage the two streams which had to be bridged measured together about 500 yards across. That on the left bank between Rohrī and Bakkar was about 380, and the other, between Bakkar and Sakkar, about 120 yards in width. To provide against possible treachery, the party which went to take possession of the fort was provided with two bags of powder to blow in the gate. Everything, however, passed off quietly, and the British flag was hoisted by the side of that of Mīr Rūstam on one of the towers. Bakkar was accounted the key of upper Sindh, and its possession by the British secured for them the passage of the Indus, and saved them a strong point for organising their further advance against Afghānistān.

The actual passage of the Indus at Bakkar was provided for by a bridge of 74 boats. A description is to be found in Vol. IV. of the *Professional Papers of the Royal Engineers*, quarto edition.

Between 16th and 20th February the whole of the Bengal force marched from Sakkar to Shikārpūr, a distance of 26 miles, and there found the Shah, who had arrived a month before. There were now assembled at Shikārpūr 15,500 troops, and Hough says that the camp followers must have made the total to be fed up to 100,000 people.

Great difficulty was now felt about camels. The Bombay column had been marching close to the Indus, and was thus able to manage with a small amount of land transport, depending on its boats for supply. But on leaving Shikārpūr this resource would be cut off, and it was necessary to allot to the Bombay force a part of the camels with the Bengal column.

Reports had been received that the Kandahār Sardārs, who had had ample warning, were occupying the Bolān Pass. It was therefore resolved to push on without waiting for the Bombay troops, in order to secure the pass. This, as we shall presently see, led to a halt at Shālkot, where there were no supplies. This was very unfortunate, as it seriously affected the health and efficiency of the troops.

On 23rd February the Bengal force began to march from Shikārpūr. The force, except the 2nd brigade, which was to join the Shah's column, was divided into five columns to march on consecutive days. At the second march a scarcity of water was reported in front, and a modified order of march was issued dividing the Cavalry from the Horse Artillery. The difficulties of this tract of country were then much greater than they are under British rule. Irrigation has been greatly extended, wells dug, and flourishing villages exist where all before was desert. On the third day the desert called the Pat had to be traversed by a march of 26½ miles. The troops marched at night and performed the march (says Colonel Hough) without suffering in the least.

The whole distance from Shikārpūr to Dādar is 146 miles, and was usually made in 10 marches, but the Head-quarters of General Cotton took 16 days owing to want of water. Over some of the marches Infantry had to be moved by detachments and the Cavalry by wings of regiments.

Up to Shikārpūr, Shah Shūja had taken the lead: he now resigned it to the British troops as being better able to cope with an enemy. The 2nd Bengal Brigade was left to march with him. The Bengal column on moving from Shikārpūr carried with it provisions for one and a half months, and rum for the British troops for three months. The road taken was the old Kāfila route. At the present time troops avoid this line and march by Shahpūr, which is more to the east. The force lost a good many camels, carried off by the Balūch robbers, during this passage, and others from want of water. Before reaching Dādar the followers had to be put on half rations (March 8th).

Provisions promised by the Khān of Kalāt were expected at Dādar, but nothing was found there, though he had written calling for an official to be sent to take them over.

The Head-quarters of Sir Willoughby Cotton having reached Dādar on March 10th, a reconnoitring party, consisting of one troop of Native Cavalry and three companies Native Infantry, under the Deputy Quarter-Master General, Major Garden, was sent on into the pass, and the Engineers followed to remove obstacles on the road. Sir Alexander Burnes accompanied the reconnoitring party, which moved through the pass without opposition, and encamped in the Shāl valley.

The Bengal force halted five days at Dādar, continuing its march on the 15th March.

On that day the relative positions of the different parts of the expedition were thus:—

The Bombay column, which had detached its 2nd brigade to hold

Sakkar, was nine marches in rear of Dādar, coming up by a road south of that taken by Sir Willoughby Cotton.

The Shah was on the march from Shikārpūr to Dādar, while the Shahzāda and Lieut.-Col. Wade were about five marches east of Peshāwar.

The order of march into the Bolān was peculiar, the advanced column consisting largely of mounted troops.

First day.—16th March.—Head-quarters with 2nd Troop H.A.; a Regiment of Cavalry; 13th Light Infantry; 2 Battalions of 1st Brigade; half Risāla Local Horse.

Second day.—Remainder of Cavalry; 1 Battalion of 1st Brigade; No. 6 Light Field Battery: half Risāla Local Horse.

Third day.—2 Battalions of 4th Brigade; a Risāla Local Horse; the Field Hospital.

Fourth day.—1 Battalion of 4th Brigade, with Commissariat Field Depôt.

The Infantry to march by sections right in front. Artillery and Cavalry, in time-honoured phrase, were ordered 'to conform.' The 2nd brigade is not mentioned, as it marched with Shah Shūja. Two companies of Infantry were to march parallel to the guns, to help them over difficult places, but there is no mention anywhere of flanking parties. The generals seem to have trusted too much to the assurances of the Politicals that everything had been done to smooth their advance, and to have marched as if in a perfectly friendly country, without any military precautions. The pass seems to have been viewed very much as Ranjit Singh is said to have viewed the Khaibar —'as an obstacle to be forced by pushing a column of troops into it, just as you might push over a narrow bridge.' In none of the accounts is there any mention of flanking parties or patrols, although the country admits of both, or at any rate of the latter. Besides, it is specially mentioned that the officer commanding 37th Native Infantry was obliged to crown the heights on nearing the head of the pass, in order to dislodge some Khākars who annoyed his column; from which we may infer that the precaution was not usual. For the want of these precautions the Balūch robbers robbed the baggage, murdered the followers, and carried off a large number of camels.

Moreover, the *Etappen* arrangements, as the Germans say, were most defective, or, rather, did not exist. When the Head-quarters of the Bengal force were at Sir-i-Āb, one march from Shālkot, they received on the same day not fewer than four dāks, 'which had escaped *by good fortune* (says Havelock) from the predatory tribes which infested the rear;' and again, on the next day, the Head-quarters of Sir John Keane (who was the Commander-in-Chief of the expedition) were *supposed* to be at Dādar; 'but,' says Havelock, who was A.D.C. to General Cotton, 'the continued interruption of our dāk communication left us, at this critical period, in doubt even as to that fact.' And this when the Bengal force was pushing on to secure the passage, and liable to be attacked at any moment by the enemy from Kandahār! Lieut.-Col. Hough says the entrance to the pass from Dādar might be disputed for a short time, but there would not be much difficulty in crowning the heights, which are broken hills on each side.

From Dādar, the first two stages were Kohan Dilān and Kirta. Here the road follows the Bolān stream. Road, properly so-called, there was none: it was merely a narrow track through the stones, the rest being untrodden. The ascent on these two stages is not considerable, Dādar being 740 feet above the sea, and Kirta only 1,080, while the distance is 21 miles. The next two stages are through stony valleys to Bibi-Nāni and Āb-i-gūm, distance 18 miles. The ascent is now more severe, the rise from Kirta to Āb-i-gūm being 1,500 feet. At Āb-i-gūm the road rejoins the Bolān river, which it follows for about 9½ miles to the next halt, called Sir-i-Bolān. Sir-i-Bolān is not (as its name might seem to imply) the summit of the Bolān *Pass*, but it is the head, or source, of the Bolān stream, or, at any rate, there is a large spring here which feeds the river. The march from Āb-i-Gūm to Sir-i-Bolān is a very severe one. The rise in the 9½ miles is close on 2,000 feet, and the resulting average gradient is 1 in 25. With such a slope to climb, and remembering that the so-called road was merely the bed of a torrent, from which the biggest of the stones had been removed, one is not surprised that the destruction of horses and camels in accomplishing it was very great, and that eight horses and the assistance of the Infantry hardly sufficed to bring the guns into camp. The Horse Artillery were five hours in doing the 9½ miles.

Ten miles from Sir-i-Bolān, by a more moderate incline, brought the exhausted troops to the summit of the pass. They then advanced for 2½ miles, and encamped at 12½ miles from their last halting place, in the Dasht-i-Bedaulat.

During nearly the whole passage of the Darra (or pass) the troops suffered from a severe and cutting wind and very considerable changes of temperature, the thermometer ranging from 50° or so in the early morning to 80° or more in the afternoon. The advanced party which accompanied Major Garden lost a number of camels and other animals in a snowstorm near Sir-i-Bolān. Hough remarks that it is not safe to enter the pass very early in March, as there is great danger of snowstorms and very cold weather.

The loss to the Bengal column in camels, camp followers, and horses, was very severe in the eight days it passed in the Bolān. The unfortunate camp followers (as we have seen) were put on half rations at Shikārpūr, and were, therefore, unable to resist the hardships to which they were now exposed. The horses and camels, which were already jaded by a march of over 800 miles from Fīrozpūr to Dādar, had likewise been badly fed and died in great numbers.

The Bolān, viewed as a pass, does not appear to be a very formidable one. It is true that some writers have described it in rather sensational terms, and especially those who seem to take a pleasure in making the worst of everything connected with the campaign.

But Captain Neill, who marched with his regiment (the 40th) to Kandahār, in 1841, says he was disappointed; the general appearance and strength of the pass fell very far short of what he had conceived from the descriptions of those who had gone before.

An officer who has been often through the pass in the last three or four years confirms this view. Captain Neill concludes his account by saying, that during his march the Infantry never once had been required to assist the guns. There can be no doubt, however, that the road would have been much improved during the two years which elapsed between the passage of the Bengal force in March 1839 and that of Brigadier Valiant's brigade in March 1841. Both experienced the same want of forage, and both suffered from the same severe winds.

On the day that the Bengal Head-quarters reached the Dasht-i-Bedaulat, the Bombay force was at Gandāva, five marches from Dādar and 11 in rear of the Bengal troops.

The Dasht-i-Bedaulat was covered with wild thyme and southern wood. Havelock says they were well pleased to see soft clay under their horses' feet instead of loose pebbles or hard limestone rock.

Red and yellow tulips and irises were growing on the plain.

After one day's halt the march was continued, on 23rd, to Sir-i-Āb, near the head of the Lora river. The road lay over the Dasht with nothing but wild thyme, crocuses, and tulips to be seen. At Sir-i-Āb there was then 'no human habitation.' Now, there is a flourishing village of Dehwars and tame Khākars, and rich gardens and orchards. On 26th March, Sir Willoughby Cotton reached Shālkot, which is described as 'a miserable mud town with a small castle on a mound, on which was a small gun on a rickety carriage.' This was in 1839, and I am informed that the gun on a rickety carriage (an iron three-pounder) is still there. Peach, plum, apricot, and almond trees were in blossom, and other fruits of a temperate climate grow there.

The scenery of Shālkot is fine. It is thus described by General Nott, writing a few days later:—

'This is the most delightful climate I have ever experienced; thermometer about 58° morning and evening, and rises to 66° during the day. I am encamped in a rich and beautiful valley, which is about 20 miles in breadth and 48 in length, commencing at the outlet of the Bolān Pass, and running to this place. The plain on which we are encamped is intersected by rivulets of the finest water; the gardens filled with fruit trees, among which are the apple, plum, apricot, and others. The rose and sweetbriar abound. I cannot walk in any direction from my tent without passing over a variety of flowers, and, as this is the spring in Afghānistān, they are in full bloom. This rich valley is surrounded by lofty mountains, the tops of which are covered with snow. The wind is at this moment gently blowing from a high mountain on my right hand; this breeze qualifies the heat of the valley at midday, and renders it most delightful; but, oppression, cruelty, and plunder having for ages borne sway, the country is almost depopulated; villages are few, and the inhabitants appear to cultivate but just enough to live on.'

The Bengal force had to halt 11 days at Shālkot, waiting for the Commander-in-Chief. No supplies were procured from Kalāt, though they had been promised by the Khān and Sir A. Burnes had been to Kalāt to obtain them. On the 28th March, Sir Willoughby Cotton was, therefore, obliged to put his men on reduced rations. Europeans received 1 lb. flour in lieu of bread. Native soldiers the same. In addition, the Europeans had 1 lb. of mutton daily. The unfortunate followers were reduced to ½-lb. of flour only. Sheep, at this time, were to be got at 3 rupees each.

Two days later, the Commissariat had no more grain for the Artillery and Cavalry horses. Commanding officers were ordered to purchase such supplies as they could. Some of the green barley crops in the neighbourhood had to be taken as forage.

On 7th April the advance was resumed under the immediate command of Sir J. Keane, General Nott being left to command at Shālkot, with a garrison consisting of one battalion of his brigade (the 41st Native Infantry), a battalion of the Shah's Infantry, and a risāla of Horse.

The distance from Shālkot to Kandahār is 147 miles. It is ordinarily divided into 14 marches, but on this occasion was not accomplished under 20 days. Men and horses were now half starved. Such was the state of the Cavalry that, on the day they marched out, sixty of the horses had to be destroyed, owing to their being two weak to proceed. The principal obstacle between Shālkot and Kandahār was the Khojak Pass, the summit of which is 7,450 feet above the sea. The descent on the north side was very difficult, the fall from the summit to a place called Chaman Choki, $2\frac{1}{2}$ miles distant, being nearly 1,800 feet. The gradient is in some places one in three. All the Artillery, and some carts which accompanied the force, had to be dragged up and let down by hand. The passage of this defile occupied three days, on account of the narrowness of the road and the enormous quantity of baggage. The arrangements were bad. Two batteries and six regiments, with all their baggage, in addition to making a march of 11 miles, were ordered to march over this difficult pass on the same day. The result was utter confusion; troops, guns, and baggage were jammed together in a road which only admitted of one camel passing at a time. Havelock says that many camels which fell down exhausted had, with their loads, to be pushed into the ravines.

The Artillery park, which crossed a week later, fared even worse. Twenty-seven thousand rounds of ammunition, and 14 barrels of powder were lost, besides an immense quantity of baggage, camels, tents, and other things. Yet we find General Nott was able to cross the pass in the following November with the loss of only four bags of grain.

It was not until the troops had made eight marches from Shālkot that forage was found in sufficient quantity to warrant an order to respect the growing crops. The horses, meanwhile, had been dying by scores. Sir G. Lawrence relates that on 10th April his regiment, the 2nd Light Cavalry, lost on one day no less than 58.

Again on the 22nd (owing to some mistake) the cavalry brigade did not, on reaching its halting ground, find the watering place immediately. So, after marching 12 miles, the Brigadier pushed on 10 miles more till he came to a river, men and horses suffering dreadfully. Fifty or sixty horses fell down and died, and the men of the 16th had to dismount and goad on their horses with the lance. The thermometer in the afternoon of this day stood at 102° in the shade.

On the 20th April, the chief of the Kākar tribe, Hāji Khān, came into camp and tendered his submission to Shah Shūja. His defection, added to other dissensions, caused the breakdown of all opposition at Kandahār. The Sardārs, Kohandil Khān, Rahmdil Khān, and Mehrdil Khān, had come out about 25 miles from Kandahār to oppose the British, but on Hāji Khān's desertion, they broke up their army and retired to Kandahār. From that place they fled on 24th April, with a small following, to Girishk, and on the next day Shah Shūja-ul-Mulkh entered Kandahār.

It appears to have been very fortunate for the British that no opposition was met with at Kandahār. The Head-quarters arrived there with Horse Artillery, Cavalry, and 1st brigade, on 26th April, but on that day the 4th brigade and park were four marches in rear, whilst the Bombay column was not yet clear of the Khojak Pass.

The Cavalry and Artillery were in a state of temporary inefficiency, the horses having been 26 days without grain of any sort. They had lived mostly on green crops. The Bengal Cavalry Brigade had lost, up to Kandahār, 350 horses out of an establishment of 2,560. The loss of the Bombay Cavalry was not so heavy—150 out of 1,950. All the troops had been on half rations for 28 days, and had meanwhile undergone great exertions in the passes, and consequently were much reduced in strength, whilst the unfortunate camp followers had been on a very small ration for 48 days. To crown all, there were only supplies for about two days at half rations left with the Commissariat.

Under these conditions, it is evident that a very moderate amount of resistance at Kandahār might have been well-nigh fatal to the whole force. Even a demonstration which would have forced Sir John Keane to halt and form up his straggling columns would have led to very serious results.

At Kandahār a halt of two months was made to allow the crops to ripen, and to rest, recruit, and refit the army. Remount committees were formed for purchase of horses, and the camels were all sent away to a distance to graze, escorted by a detachment of Cavalry and Infantry. The men were in great want of rest and good food, and at first provisions were very scarce. On 12th May, or a fortnight after the occupation of Kandahār, so little flour had come in that it sold at one ser * for a rupee, or about a shilling a pound.

In May there was a great deal of sickness, especially amongst the Europeans, but by the middle of June men and horses were regaining their strength. The great difficulty was to get provisions for the advance, and camels to carry them. Not less than 20,000 camels had died or been lost in the Bengal force since it left Firozpūr. A convoy of Lohāni camels carrying 20,000 maunds † arrived on 24th June, but the bargain had been only to convey the provisions to Kandahār, and as the men could not be induced to proceed, the whole had to be left there, and the force marched again on half rations.

During the halt at Kandahār a mixed force of 1,000 men and some

* A ser equals 2 lbs. † A maund equals 80 lbs.

heavy guns had been sent under Brigadier Sale to reduce Girishk. The place, however, was evacuated before the force arrived.

Sir John Keane marched from Kandahār on 27th June, leaving a garrison consisting of two battalions and a company of Bengal Artillery, a troop of the Shah's Artillery, with a small force of Cavalry. The regular battalion was the 37th Native Infantry, belonging to Lieut.-Col. Roberts's (the 4th) brigade. The other battalion belonged to the Shah's force. The army marched in three columns as follows:—

First column.—Two troops Horse Artillery; the Cavalry (combined) Division; the Camel Battery; the Engineers; the 1st Bengal Brigade; the 4th Bengal Local Horse; the Commissariat Field Depôt.

Following this first column went the Shah with his troops, and a troop of Bombay Horse Artillery in attendance. On the third day came the second column, under Brigadier Roberts, consisting of the 4th Bengal Infantry Brigade, the Bengal Artillery Park, some Local Horse, and the Field Hospital.

Major-General Willshire marched the day after Brigadier Roberts with the Bombay Infantry Brigade, a Battery, and the Pūna Horse.

The total British force at Kandahār before the move was 8,800 fighting non-commissioned officers and men, of which about 600 remained in garrison, and they had 30,046 recognised followers attached to the army. To protect the baggage on the march the Major-General commanding the Cavalry was directed to have parties at intervals of one mile, right and left of the road. The European battalion at this time averaged 520 non-commissioned officers and men. The 16th Lancers were 400 sabres, while the Native Cavalry regiment averaged somewhat less than that. The four 18-pounders, the only breaching guns the army possessed, were, after having been conveyed at so much trouble and cost through the Bolān and Khojak Passes, now left behind at Kandahār. This was done in consequence of the assurances of the 'Politicals' that no opposition would be met with towards Kābul. Sir John Keane had been advised to proceed with a force much less than what he took. He afterwards stated in one of his despatches that he had no reason to regret having acted on his own judgment as to the amount of his force.

The country marched over was stony and cut up by nullas, the road crossing all the drainage from the north into the Tarnak river. Kalāt-i-Ghilzai was at this time in ruins, and no opposition was met with between Kandahār and Ghaznī, though two hostile Ghilzai chiefs Abd-ul-Rahmān and Gūl Muhammad, marched in columns on the left and right of the force, respectively, all the way from Kandahār, Abd-ul-Rahmān with 1,500, and the other with 3,000 horse.*

On 21st July, Sir John Keane arrived in front of Ghaznī. The second column, under Brigadier Roberts, had pushed up to join him on 19th, and Major-General Willshire, with the third, came into camp at midnight on the 20th. An attack by Afzal Khān (eldest son of Dost Muhammad) had been announced for that night, and the whole force had bivouacked ready to fight.

The order of march for the 21st July is worthy of notice, from being so very unlike what a general of the present day would be likely to adopt. It was this :—

The army marched in three columns at 4.30 A.M.

The Artillery followed the main road with the Sappers and Miners.

The Cavalry marched on the *right* in column of troops at quarter distance *right* in front.

The Infantry on the left in column of companies *left* in front. Hough says it was supposed that the enemy would move from Ghaznī towards our left front, so that the Infantry by being left in front could easily form to the front.

The columns moved parallel to one another, and preserved such distances between each as would enable the troops to form to the front or to either flank. The rear guard consisted of three companies Infantry, one troop, and the whole of the Local Horse. Afzal Khān, with 3,000 horse, was hovering about.

As the Head-quarters advanced a deserter came over in one Abd-ul-Rashid Khān, a nephew of Dost Muhammad, who gave valuable information. According to Sir J. Kaye, it was Mohan Lāl, the chief munshi of the Mission, who gained over this man, and, strangely enough, Kaye makes it a subject of reproach against Mohan Lāl. From Abd-ul-Rashid the Commander-in-Chief and his commanding engineer, Captain Thomson, learnt that all the gates *except* that on the Kābul side had been bricked up.†

* Doubtless Major-Gen. Thackwell would have gladly chastised them for their insolence, but his brigade was as yet scarcely efficient. It is noted by Hough that ten horses were required in places for the Horse Artillery guns, owing to *the low condition* of the animals.

† Kaye states (Book III., Chapter iii., of *The War in Afghānistān*) that 'the military historians leave it to be surmised by the reader that the knowledge of this important fact was derived from the reconnaissances of the British commander and his engineers.' This charge against the military historians is unfounded. Lieut.-Col. Hough, whose book is frequently referred to by Kaye, mentions the fact at pp. 165 and 195. Outram prints at full length Capt. Thomson's report, in which the fact is distinctly stated, as it also is by Havelock at pp. 55 and 63, Vol. II. All these three were published when Kaye wrote.

An account of the storming of Ghaznī appeared in the quarto series of the *Professional Papers of the Royal Engineers*, Vol. IV., in 1840. It is by Captain Thomson of the Bengal Corps, who was the Commanding Engineer with Sir John Keane. The report is accompanied by an interesting view of the place, sketched by Lieutenant (afterwards Sir Henry) Durand. Captain Thomson says: 'The accounts of the Fortress of Ghaznī, received from those who had seen it, were such as to induce His Excellency the Commander-in-Chief to leave in Kandahār the very small battering train then with the army, there being a scarcity of transport cattle. The place was described as very weak, and completely commanded from a range of hills to the north.' I have already mentioned how much Sir John Keane was misinformed by the 'Politicals' as to probable opposition.

Captain Thomson continues: 'When we came before it, on the morning of the 21st July, we were very much surprised to find a high rampart in good repair, built on a scarped mound, about 35 feet high, flanked by numerous towers, and surrounded by a faussebraye and a wet ditch. The irregular figure of the enceinte gave a good flanking fire, whilst the height of the citadel covered the interior from the commanding fire of the hills to the north. In addition to this, the towers at the angles had been enlarged, screen walls had been built before the gates, the ditch cleared out and filled with water, and an outwork built on the right bank of the river so as to command the bed of it.'

After clearing some gardens of the enemy a nearer view was obtained. This, says Captain Thomson, 'was not at all satisfactory. The works were evidently much stronger than we had been led to expect, and such as our army could not venture to attack in a regular manner. We had no battering train, and to besiege Ghaznī in form would require a much larger one than the army ever possessed. The great command of the parapets, from 60 to 70 feet, with a wet ditch, were insurmountable obstacles to an attack by mining or escalade.'

'The fortifications were found equally strong all round, the only tangible point observed being the Kābul gateway, which offered the following advantages for a *coup de main*. The road to the gate was clear, the bridge over the ditch unbroken, there were good positions for Artillery within 300 yards of the walls on both sides of the road, and we had information that the gateway had not been built up, a reinforcement from Kābul being expected.'

Captain Thomson accordingly proposed to make a dash at this gate, blow it open, and admit a storming party, and this plan was approved by the General.

The road from Kandahār, as may be seen by the diagram (*see* Plate IV.) approaches Ghaznī from the south-west, whilst the Kābul gate is on the north-east. It was necessary to march round to the north and east. This was effected in the night of the 21st by marching (*see* Sir John Keane's despatch) in two columns ,to the right and left of the town. This movement was not effected without great confusion. The troops got to their new ground late at night, but the baggage and rear guard lost their way in the dark, and did not get in till morning. Fortunately neither the garrison nor the Cavalry of Afzal Khān made any attack.

The arrangements for the storming were as follows:—

The Artillery (28 guns) were to take up a position on the hills north-east of the town, accompanied by the Sappers and Miners, and six companies 35th Bengal Native Infantry as escort.

The storming column was placed under the command of Brigadier Sale, C.B. (of 13th), and was formed with an advance, a main body, and a support.

The advance, under Lieut.-Colonel Dennie, C.B., consisted of four companies, one from each of the European regiments present, viz. 2nd Queen's, 13th, 17th, and 1st Europeans (now 101st). The main body, under the immediate orders of the Brigadier, was formed by the remaining seven companies each of the 1st Europeans, 2nd Queen's, and also the seven companies of 13th formed as skirmishers on the flanks. The support was furnished by the rest of the 17th Foot.

Three companies of the 35th Bengal Native Infantry were to move round to the south of the place and make a false attack at three A.M. A regiment of Cavalry (3rd Bengal Native Cavalry) was also to move in that direction to cut off men seeking to escape from the town.

The explosion party was to advance shortly before daybreak, or at three o'clock in the morning, covered by the seven companies of 13th Light Infantry in skirmishing order, who were to establish themselves in front of the gate and keep down any fire which might be directed on the Engineers' party. As soon as the explosion was heard, the Artillery was to open a hot fire on the ramparts and citadel; and when the Engineers found the breach practicable, the advance was to be sounded for the storming column to push on. The Brigadier (Stevenson) commanding the Artillery was to arrange a signal when the column passed the gate, to warn the battery officers to turn their fire on the citadel only. The 16th, 35th, and 48th Bengal Native Infantry were in reserve, under Sir Willoughby Cotton; General Willshire's Division being broken up for the occasion he joined the staff; while the 19th Bombay Native Infantry guarded the Kābul road.

All these arrangements were very precisely carried out. The storming columns moved from camp (in column of companies at quarter distance right in front) a little after two o'clock, and at the appointed time all were in their places. The explosion was successful, and the place was entered after a short but severe struggle between Briton and Afghān amidst the fallen timbers of the gateway.

The extended companies of the 13th closed, and followed the main body into the gate. Two battalions turned to the left into the town and two to the right against the citadel, where no defence was made. The governor, Haidar Khān, son of Dost Muhammad, was taken with 1,500 men, whilst over 1,000 were killed, some by the Cavalry outside. The loss on our side was 17 men killed and 18 officers and 147 men wounded. The moon was only three days from full at the time, so that the preparatory movements must have been clearly seen. But the governor, it appears, expected an escalade, and had given orders not to fire a shot until the heads of the British troops were above the walls. He did not understand the probable effect of the explosion even when he heard it: and to show how ignorant the Afghāns were at that time, it may be mentioned, that though they used blue lights, they burnt them *on* the walls instead of throwing them over amongst the attacking troops.

The troops behaved exceedingly well; no excesses were committed, and the women were honourably treated.

No less than 500,000 lbs. of flour or wheat were found in the fortress—a quantity which would have sufficed to feed the garrison of 3,000 men for more than three months. This must have been a very acceptable windfall to our exhausted Commissariat. Shah Shūja was greatly surprised and delighted at the speedy capture of the place, which was deemed by the Afghāns to be impregnable, and which he had advised Sir John Keane to pass by without risking an attack. His agreeable surprise at the fortunate result must, one may venture to think, have been shared by the General himself; for had the explosion failed or the storming column been repulsed, there does not appear to have been any available means of reducing the place.

It is time to turn to Lieut.-Col. Wade's operations, which were now making themselves felt. Colonel Wade, as we have seen, had the general political and military control both of the Shahzāda's force and of the Sikh contingent. He reached Peshāwar on 20th March, just as the Bengal column emerged out of the Bolān Pass. At Peshāwar he was busily employed for three months organising his irregular levies and negotiating for the adherence of some of the Afghān tribes to the cause of Shah Shūja. Amongst other things he was able to set on foot a rising in the Koh-i-stān, a district from which Kābul receives supplies of grain. Early in July he was ready for advance, and hearing of the march of Sir John Keane from Kandahār, decided that it was time for him to move forward through the Khaibar. The whole force at his disposal amounted to over 10,000 men, the Shahzāda Taimūr's force being about 4,500, and the Sikh contingent under Colonel Shaikh Bassāwan (General Ventura not accompanying the force) 6,000.

Opposing Wade was Muhammad Akbar Khan, near Jalālābād, with 2,500 men and 14 guns. He did not take an active part in the defence of the pass, but the Khaibaris preferring Afghān to Sikh domination, permitted him to establish a garrison in the fort of Ali Masjid.

From Jamrūd to Ali Masjid there are two roads. The distance is eight miles by the Shādi Bajiāri, or northern road, and 14 miles by the Kadam (the southern) road. Wade chose the southern road. He marched from Jamrūd on 22nd July, and employed half his force in columns right and left on the heights, whilst the rest kept the road. He threw up *sangahs* (stone breastworks) as he went along, to secure the ground that was gained, and on 27th occupied Ali Masjid, from which the garrison fled after he had succeeded in gaining a position from which he shelled the fort. His loss in killed and wounded was about 180, that of the enemy considerable. The fort was only about 50 yards by 20, and had six little bastions. Besides this there was an enclosed space about 100 yards by 60 for men and stores. After taking Ali Masjid, the Shahzāda's force met with no more opposition, and on 3rd September it marched into Kābul. Although the force directed by Colonel Wade had not to encounter any very great opposition, it nevertheless was of good service in the campaign by distracting the attention of the Amir, and preventing his moving against the main army during its advance from Kandahār.

The fall of Ghaznī paralysed the defence of Kābul. Afzal Khān, who had been hovering with his Cavalry round the British camp, fled in dismay; and the Amīr, finding that his supporters were getting demoralised, sent his brother, Jabbar Khān, to treat for terms. As, however, Jabbar Khān insisted on Dost Muhammad being made Shah Shūja's Wazīr, his negotiation came to nothing.

Sir John Keane marched from Ghaznī in two columns on 30th and 31st July, crossing on the first day the summit level, 9,000 feet above the sea, which separates Ghaznī from the Kābul valley. From Ghaznī to Kābul he made seven marches. At the third march intelligence was obtained of Dost Muhammad's intention to take up a position at a place called Maidān, 27 miles from Kābul, and a day's halt was made to allow Major-General Willshire, with the second column, to close up. This position of Maidān would cover the road to Bamiān, which branches north-west from the Ghazni-Kābul road at Argandeh, 13 miles out of Kābul.

Dost Muhammad did not succeed in reaching his intended position. At Argandeh he found that his troops were not to be trusted. The Kazlbāshis in particular (never cordial supporters of the Dūrāni power) were deserting in large numbers. He attempted by a spirited and stirring address to recall his men to their duty, but all in vain. Deserted by nearly all his troops, he was forced to abandon his artillery (23 guns), and fled, with a small escort, along the road to Bamiān on the evening of the 2nd August. It was not till the following day that the flight of the Amīr was known in the British camp. Thirteen officers, headed by Captain Outram, with 250 men of the Native Cavalry, volunteered to go in pursuit, and Hāji Khān (the Ghilzai chief who came over to Shah Shūja before Kandahār) was sent as guide with 500 Afghāns. Hāji Khān was a traitor, and took care that the party should not overtake the Dost. They did not start till nightfall, owing to delays which he interposed, and though they continued the pursuit till the 9th, on which day they were at Bamiān, they could not come up with the Amīr.

The British force met with no further opposition, and on the 6th August encamped under the walls of Kābul. Next day Shah Shūja-ul-Mulkh made a triumphal entry into the city, and took up his residence in the Bāla Hisār.

After some repose at Kābul, the force destined for the occupation of the country was distributed in accordance with the tabular statement, Appendix II. When Dost Muhammad first fled it had been expected that two brigades of Infantry, one in Eastern and the other in Western Afghānistān, would suffice, in combination with his own army, to support Shah Shūja until he was firmly established on the throne. But before long it seemed that Dost Muhammad had obtained so much power in Kundūz that he was not unlikely to make that territory the basis of further operations, and it was therefore decided to keep the whole of the Bengal Infantry division, the camel battery, and 2nd Light Cavalry in the country. Even this force seems to us a very slender one, but it must be remembered that the Shah had brought over 10,000 men of all arms from Hindustān, and was of course expected to increase his force.

This disposition of the troops was published in General Orders on 9th October.

The Bombay column, under Major-General Willshire, had already left Kābul three weeks. It had marched on 18th September, but instead of retracing its steps by Kandahār, it quitted the Ghaznī-Kandahār road at Mukūr, six marches from Ghaznī, and went through the Ghilzai country by Tokarak and Kachh Toba to Shālkot. In this way it had the advantage of going through a fresh country instead of one already exhausted by the passage of a large body of troops, and, as General Willshire says in his Kalāt despatch, 'great additions were made to our geographical knowledge of the country, besides great political advantages obtained in peaceably settling those districts.'

General Willshire marched along the route (*see* Plate II.), passing near the Salt Lake. Captain Outram, one of the political officers, had been sent with some Afghān Horse from Kābul up the Loga Valley and over the Kharwar Pass, south of Kābul, to act against some of the Ghilzai chiefs, who refused to acknowledge the changed *régime*. When he arrived abreast of Ghaznī, Major McLaren (commanding there) came out with half a battalion and some horse, and encamped at Kalālgū, in the Zurmat district, about 32 miles east of Ghaznī. Combined with Captain Outram's detachment, Major McLaren's force destroyed a tribe of robbers called Kanjaks, and captured their chief.* Major McLaren mentions that on his return to camp, the more peaceable inhabitants testified their delight at the destruction of this clan by cheering his detachment. General Willshire's column met with no opposition, whilst its presence and the moral support it afforded no doubt rendered Captain Outram's movements much easier than they would otherwise have been. Captain Outram acted with his Irregulars as a sort of flanking party to the main column. Captain Outram's narrative affords an instance of the strange position held by the 'Politicals' whilst operations were going on. At one time he is accompanied by a force under Major McLaren, at another by a mixed force under Lieut.-Col. Stalker; yet it is always 'I' did this or that, even when it is distinctly a question of a military operation, and the force is commanded by an officer senior to himself.

General Willshire reached Shālkot on 31st October, and marched again on 3rd November. Owing to a reported deficiency of water and forage on the road, and the expected submission of Mahrāb Khān, he left great part of his force there to go down to Sindh by the Bolān. The force he took consisted of:—

| | |
|---|---|
| 2 guns, Bombay Horse Artillery . . . . . . | 36 men |
| 4 „ Shah's Artillery . . . . . . . . . . | 50 „ |
| 150 Local Horse . . . . . . . . . . . . | 150 „ |
| Her Majesty's 2nd (Queen's) . . . . . . . | 290 „ |
| „ 17th Regiment . . . . . . . | 336 „ |
| 31st Bengal Native Infantry . . . . . . . | 329 „ |
| Bombay Sappers and Miners | |

The distance from Shālkot to Kalāt is 111 miles, which was made in 10 marches.

* *See* Havelock's *War in Afghānistān*, Vol. II., App. 20.

On 13th November (1839) General Willshire arrived before Kalāt. (*See* Plate V.) He found that the Khān had occupied some high ground which flanked the road to the town, with Infantry and five guns. This high ground is about 200 yards from the road, and extends to 600 yards from the north front of the town, and is divided into three heights. The guns were protected by small stone breastworks, locally called *sangahs*. General Willshire advanced in three columns, the 2nd Queen's and 17th on left of the road, and 31st Native Infantry on the right. His six guns were brought into action on the road 400 yards from the nearest height. To the left lay a plain with gardens and enclosures. Two companies were detached, one from each of the European regiments, under Major Pennycuick of the 17th, to a garden about 500 yards left of the road, while two other companies kept up the communication of these with main body.

Four companies were then detached from each of the three battalions, forming three columns, one to move against each height, the whole under Brigadier Baumgardt of the 2nd Queen's. Major-General Willshire brought on the remaining eight companies in reserve.

The enemy did not await the attack of the Infantry, but fled from the hills after receiving the fire of the Artillery. An attempt to enter the town with the flying enemy, made by the Queen's and 17th Regiment, was unsuccessful, as the gate was closed before the troops reached it.

Four guns were then taken on the heights to fire on the north-west part of the town and on the citadel, while two were brought to 300 yards from the Kandahār gate to blow it in. This they soon effected. Then the companies under Major Pennycuick, which had meantime moved on, rushed in and established themselves in the gateway.

The rest of the storming columns followed, and fought their way through the town up to the citadel. General Willshire brought up the reserve, and sent men round by the western and others by the eastern face to the south side of the town to intercept the retreat of the garrison. After some delay the troops in the town forced their way into the citadel, where Mahrāb Khān was killed with many of his chiefs, gallantly fighting sword in hand.

The British loss was heavy—34 killed and 138 wounded, or 172 *hors de combat*, out of a total of 1,254 engaged. The garrison is said to have numbered 2,000 fighting men.

General Willshire says in his despatch: 'The defences of the fort, as in the case of Ghaznī, far exceeded in strength what I had been led to suppose from previous report, and the towering strength of the citadel was most formidable, both in appearance and reality.'

After halting for a week, General Willshire proceeded to Kotri in Sindh, by the way of the Mūla Pass. The troops he had left at Shālkot had meantime marched down by the Bolān.

Sir John Keane, with the remaining Cavalry and Artillery of the Bengal army, had left Kābul on 15th October, and returned to India by way of Peshāwar.

The objects with which the campaign of 1838-9 was undertaken now seemed to many to have been fully attained. Shah Shūja was reseated on the throne of his fathers, and it was confidently expected that in a short time the British force might be entirely withdrawn from Afghānistān. How this expectation was disappointed, and what befell our troops during the occupation of Afghānistān and the campaign of 1842, must be left to a future lecture.

## Occupation of Afghānistān, 1840 and 1841.

In my last lecture I brought the narrative of events down to the end of the year 1839. I now propose to give a short account of the occupation of Afghānistān in 1840 and 1841; of the outbreak among the Ghilzais, in October 1841, and its results; also a sketch of the movements of Sir G. Pollock to relieve Jalālābād in April 1842, and of his subsequent advance on Kābul, combined with that of General Nott from Kandahār, in August of the same year.

At the beginning of the year 1840 the British force was cantoned as shown in the table. The troops in Eastern Afghānistān were under the command of Brigadier Sale, whilst those in the West reported to Major-Gen. Nott. Besides the principal posts there were small detachments at Charīkar and Bamiān, the latter consisting of a detachment of the Shah's troops with some of his Field Artillery; also the 4th Troop, 3rd Brigade of Bengal Horse Artillery with the Shah's Gūrkha regiment, and some other irregular details. This force passed the winter at Bamiān watching the road by which Dost Muhammad might reappear.

At Kābul, the 13th Light Infantry were placed in the Bāla Hisār, which stands on a hill overlooking the city from its eastern angle, and commands the whole of the city and suburbs. The Shah went off for the winter to Jalālābād, and, therefore, at this time no such objection was made to the occupation of the Bāla Hisār as was afterwards urged with such fatal results.

At Daka and Ali Masjid, small posts were established to keep up the communication between Jalālābād and Peshāwar.

For purposes of administration the country was parcelled out into political districts, which were distributed as follows :—

Kābul, where Sir A. Burnes was the agent.

Kandahār. Major Leech, succeeded in July 1840 by Major Rawlinson.

Herāt. Major Todd. This was a 'mission,' however, Herāt being quite independent of Shah Shūja under Kamrān.

Ghaznī. Major Leech, after his relief at Kandahār by Major Rawlinson.

Jalālābād. Captain Macgregor.

In the Kohistān (at Charīkar), Lieut. Pottinger, now a Local Major, while at Shālkot (or Quetta) was Capt. Bean, and at Kalāt Lieutenant Loveday.

I regret to say I have been able to obtain very little information from English sources about the work of administration during the occupation of Afghānistān. I expected to have obtained some from the India Office, but, though the records there were shown to me, I could not find any detail on this subject, as what promised (from the index summaries) to be most interesting despatches on this head are missing.

In default of these, or any detailed notice in Kaye's or the works of other English writers, I have had to fall back on a foreigner, M. Ferrier, to whom I have already referred more than once. Ferrier's testimony is, however, the more satisfactory that he is by no means uniformly favourable to the British. On the contrary, he not unfrequently reviews our conduct in terms the reverse of flattering.

Kaye describes the double system of government in these words :—

'The inherent vice of the policy we had initiated was beginning to infect every branch of the administration. . . . The Shah and his officers ostensibly controlled all the departments of civil administration; but everywhere our British officers were at their elbow to counsel and suggest; and when it was found necessary to coerce the disobedient, or punish the rebellious, then it was *British* authority that drew the sword out of the scabbard, and hunted down offenders to the death. Bound by treaty not to interfere in the administration of the country, the British functionaries were compelled to permit the existence of much which they themselves would never have initiated or allowed in provinces subject to their rule; but they were often called upon to enforce measures unpopular, and perhaps unjust, and so brought down upon themselves the opprobrium which was not always their due.'

Ferrier puts it in a less complimentary way. He says :—

'The native officers were like puppets, having no liberty of action. The English wished to be masters, but wanted courage to act openly; they were apparently neutral, but still had the presumption to mix themselves up in everything. This bastard system alienated from them both the people and the court; the Shah testified his great displeasure at it, and at last counteracted every measure that originated with the English.'

In spite of this unfavourable view of our motives, M. Ferrier says:—

'What I heard and saw in Afghānistān gave me the most profound conviction that the moment the British flag is seen in an Asiatic state, the shameless Government in force under the native ruler is replaced, if not by abundance, certainly by security and justice. However burdensome the taxation of the English may be, it is always far less so than that extorted by native princes who add persecution to rapacity. . . . . The Afghāns, so hostile to the English, sigh for the loss of their administrative system. The Sardārs, Mullahs, Saynds, and soldiers, classes who live by plundering the industrious portion of the inhabitants, were always declaiming against the English, because under them they could not practice their iniquities. The people were irritated, it is true, because their prejudices had been shocked, and rose to shake off their yoke; but now they regret them; and I have twenty times heard Afghāns speak in terms of just appreciation of what they have done for their good.'

'They remembered with gratitude their justice; their gratuitous care of the sick in the hospitals; the presents of money and clothes when they left them cured; the repairs of their public works, and the extension of commerce and agriculture owing to their encouragement; . . . and, after exhausting all their praises of their unfortunate conquerors, they would finish up with, "What a pity they were not Musalmâns like us; we would never have had any other masters!"' 'After hearing such observations,' M. Ferrier continues, 'is it not allowable to regret, in the name of humanity and civilisation, that the British power was not consolidated in Afghānistān, whatever means might have been employed to attain that end?'

Very various are the accounts given of the Afghān character. Elphinstone's are all *couleur de rose*. If we might believe him, they are a brave, good-humoured, hospitable, generous people. But Sir Herbert Edwardes, who knew them better, says that 'nothing can be finer than their physique, or worse than their morale.'

General Ferrier, who lived much among the people during his adventures in Afghānistān, describes them in much detail, and gives by no means a flattering picture. After saying that 'the Afghān is tall, robust, active, and well-formed, his step full of resolution, his bearing proud but rough,' he goes on to say, 'courage is with them the first of virtues, and takes the place of all others; they are cruel, perfidious, coarse, and without pity.' To the Afghāns (he says) 'country' and 'honour' are as empty sounds, and they sell them to the highest bidder without scruple. Again he says, 'I wish to establish the fact that the Afghāns are as incapable of a continuous course of action as of ideas; they do everything on the spur of the moment, from a love of disorder, or from no reason at all.'

'Their cupidity and avarice are extreme; there is no tie they would not break, no duty they would not desert, to gratify their avidity for wealth. . . . For it they will sacrifice all their native and independent pride; even the honour of their wives and daughters, whom they frequently put to death, after they have received the price of their dishonour. Gold in Afghānistān is, more than anywhere else, the god of the human race; it stifles the still small cry of every man's conscience, if, indeed, it can be admitted that an Afghān has a conscience at all; it is impossible to rely on their promises, their friendship, or their fidelity.'

Whilst the political officers were endeavouring, with their hands tied by the system of double government, to civilise and improve this very unsatisfactory people, the military were occupied in such matters as the construction of cantonments, roads, and so forth. The position and design of the cantonments at Kābul had such a powerful effect in leading to the loss of Elphinstone's brigade in 1841–2, that they must be described in detail.

The city of Kābul is commanded from its eastern angle by the Bāla Hisār,* the fort and residence of the kings, which stands on a hill overlooking the city. The Bāla Hisār is divided into two parts, upper and lower, and the upper, or citadel, commands the whole of the city and suburbs. Lieutenant Durand (of the Bengal Engineers) drew up a report soon after the arrival of the force at Kābul, which showed clearly that it was essential that the garrison should have military possession of the Bāla Hisār, that being the proper place for lodging the troops.

It was not without difficulty that the consent of the Shah was obtained to occupying the fortress during the first winter, when no other cover was available for the troops, and he objected so strongly to certain works of defence which Lieutenant Durand (having got possession) was pushing on that Sir W. Macnaghten yielded, and they were peremptorily stopped.

After the winter of 1839–40 a site for cantonments was taken up

* Bāla, high; Hisār, castle.

north of the city, on a piece of low, swampy ground, commanded on all sides by hills or forts. (*See* Plate VI.)

The cantonment was surrounded by a low rampart and a narrow ditch, traced on a parallelogram 1,000 yards long north and south, and 600 broad east and west, with round bastions at each angle, every one of which was commanded by some fort or hill. Attached to the north face was the mission compound, which extended the whole length of it and was 500 yards wide. Half of this compound was appropriated to the residency, and the other half crowded with buildings which entirely blinded the defence of this face, and rendered it necessary to hold the compound enclosure. The mission compound was surrounded only by a simple wall.

The western face of cantonments ran along the Kohistān road, while nearly parallel to the eastern flowed the Kābul river, at about a quarter of a mile off. Between the river and cantonments, and only 150 yards from the latter, was a broad canal. Attached to the south-west angle of the enclosure was the bazar, a mass of small houses, whilst the fort of one of the native chiefs (Mūhammad Sharif) dominated this bastion at less than 150 yards, and just beyond this fort was the king's garden, a large enclosure surrounded by a high wall. At 400 yards from the north-east angle, that is to say, within effective range of the native jezail (though not of the British musket) was another fort, called the Rikabāshi fort. The distance from cantonments to the Bāla Hisār was nearly two miles, and the road, besides running parallel to the city wall at no great distance, was commanded by the large fort of Mahmūd Khān.

The commissariat stores were placed in a small fort 400 yards from the southern face of cantonments towards the city, while the magazine was also placed outside the enclosure.

The heights of Bemarū overlooked the whole at a distance of about 800 yards from the north-west angle. Somewhat under two miles from cantonments, and to the east, lay, on the road to Jalālābād, the standing camp, separated from the plain in which lay the cantonments by a range of heights called the Siyāh Sang Heights. Until General Elphinstone, in April 1841, had a bridge made over the Kābul river, this camp was nearly four miles distant by a circuitous road near the city.

To crown all, the treasure, instead of remaining in the Bāla Hisār, where it had been placed at the recommendation of Brigadier Roberts, was, in spite of the Brigadier's remonstrances, removed to the Paymaster's house in the native city, merely to save him and his clerks a little trouble. Brigadier Roberts had also remonstrated against the site selected for cantonments, but without success.

The cantonments at Kandahār do not appear to have been selected much more judiciously than those at Kābul. I have not been able to obtain any plan of Kandahār, but Captain Neill (*Four Years' Service in the East*, p. 143) describes them in some detail. They were commanded by rugged hills only 200 yards from their front, and flanked on either side by a network of ravines and watercourses, and appear to have justified his opinion that they 'were badly planned, and difficult, if not incapable of defence. Fortunately, perhaps, their defects were not, like those of the Kābul cantonments, brought to notice by the stern logic of war.

The posts on the Peshāwar road were not unmolested even in 1839. Ali Masjid was attacked at the end of October, while Sir J. Keane was on the march down, but the attack was beaten off by Captain Ferris. A battalion of Najībs entrenched in a square *sangah*, a mile below Ali Masjid, were less fortunate. A large number were sick, and the Khaibaris, knowing they had just received pay, attacked them, stormed the breastwork, and put 400 of its defenders to the sword.

About a month after the capture of Kābul a small detachment was sent into the Hindū Kūsh to watch the road from Balkh and Khulm by Bamiān. It was by this road that Dost Muhammad had fled, and by it might at any time be expected to reappear. A troop of Native Horse Artillery, under Lieutenant Murray Mackenzie, formed part of this force which marched from Kābul on 12th September 1839. At Bamiān, Dr. Lord, the political agent, purchased three small forts at short distances apart, which were connected by entrenchments. Here the small force remained throughout the winter (at an elevation of 8,500 feet above the sea), and in the spring and summer occupied Saighān, Kamard, and Bājgāh, the last 64 miles north of Bamiān.

Turning from the Hindū Kūsh to the neighbourhood of Jalālābād, where the Envoy and Head-quarters of the army took up their winter quarters, we find a small force under Lieut.-Col. Orchard (consisting of about 800 Infantry with nine guns, and about 700 of the Shah's Cavalry) sent to take the fort of Pashūt, which lies 45 miles north-east of Jalālābād in the Kūnar valley. On the 18th January, Colonel Orchard made two attempts to capture the place by blowing in the gate with powder, but they failed owing to the rain and the powder being damp. The refractory chiefs, however, abandoned the fort, which was occupied immediately.

After this, except a small expedition against some rebellious Ghilzais in April, there were no more military operations for some months. In April, Mr. Macnaghten (for whom no enterprise seems to have been too adventurous) was proposing to send a British force beyond the

Hindū Kūsh to Bukhāra. The force which was to undertake this expedition to a point distant over 500 miles from Kābul, was 'one brigade with a due proportion of Artillery.' His attention was recalled from such far-reaching schemes to matters nearer home by troubles in Balūchistān, which began in May. A garrison of 300 men of the 3rd Bombay Native Infantry, with two howitzers, commanded by Captain Lewis Brown, had been sent in the beginning of May to hold the fort of Kahun in the Būgtī Hills 50 miles north-east of Shahpūr, and with it went Lieutenant Clarke of the 2nd Bombay Native Infantry, who commanded a party of 50 Horse and 150 Infantry, and was to bring back the camels, to the number of 600, which went with the garrison to Kahun.

Lieutenant Clarke was returning to a post called Pūlajī,* in the level country to the south, by way of the Sartaf Pass (which lies west of the Naffusk), when, at a distance of some 20 miles from Kahun, he was attacked by about 2,000 Marrīs. He and all the Infantry men, except a Havildar and 11 Sepoys, were killed, while the Sowars fled. The Infantry had been detached from Captain Brown's garrison, so that the loss of them left him with under 140 bayonets and one gun.

The small town of Kahun was enclosed by a wall with six faces, the total perimeter being about 900 yards. It had six bastions and one gate. The walls were about 25 feet high, but without any ditch. The town stands on an elevated plateau (about fifteen miles by six), where the heat was much less than in the plains. Captain Brown, who must have been an excellent officer, found the fort burning and in a wretched state; the gates had been carried away, and were found in a field two miles off. He lost no time in refixing the gates, clearing away all brushwood and corn for 200 yards round, cleaning out the tank, and removing all houses which touched the walls *inside*, so that an enemy who had gained the terreplein of the walls would have to make a drop of 25 feet, and land on sharp stakes which he planted in pits inside. He also dug a new well, and improved a small inside fort as a reduit, drilled his camp followers and armed them with clubs. Even the baniyas were pressed into the service. They filled their old grainbags with sand for use on the works. Brown occupied the fort on 12th May, and by the 24th the place was so closely beset that he had to divide his little force into four divisions, and keep every man on duty at night for fear of a surprise. Spite of this hard work and short rations, and boils, from which they suffered so much that by 14th July 90 out of his 140 men were unable to put on their belts,

* Pūlajī is 20 miles north north-west of Shahpūr.

aspect of the environing hills, crowned by the snowy summits of the Hindū Kūsh, form (it is said) a landscape which can scarcely be conceived but by those who have seen it. The villages are small but numerous, the population about 40,000 families, according to Elphinstone; whilst every man is a soldier, and the country very strong for defence.

Into this country Brigadier Sale advanced in the last week of September with a brigade consisting of the 13th Light Infantry, the 27th and two companies of the 37th Native Infantry, Captain Abbott's nine-pounder battery, two of the Shah's Horse Artillery guns, the 2nd Bengal Light Cavalry, and a regiment of the Shah's Horse; also a 24-pounder howitzer and two mortars. At Tūtan-dara, a fortified village about six miles north-east of Charikar, the enemy was found, on 29th September, strongly posted in front of the village, their flanks being supported by small detached forts. The Brigadier sent a company of 37th Native Infantry, with a small party of 13th, the Shah's Cavalry, and two guns, against the enemy's right, and two companies of the 13th, with three of Captain Abbott's guns, against the left, and having dislodged the enemy by threatening their flanks, advanced rapidly against the centre. The enemy continued their fire until the heads of the companies were within 50 paces of the walls and then fled, the garrison of the fort following the same example.

The Brigadier was less successful at Jalgāh, a fort about 16 miles east of Charikar, to which some of the rebel chieftains had fled, and which he attacked on the 3rd October. He sent about 800 Afghān horsemen on in the night to surround the fort, and followed with the Infantry and Artillery, 13th Light Infantry, three nine-pounders, two six-pounders, a 24-pounder howitzer, and two mortars. The mortars did not come up till late in the afternoon, and an attempt to breach the place with the field guns and storm it with five companies of the 13th and some detachments of 27th and 37th Native Infantry, was beaten off with a loss of 16 killed and 31 wounded. The enemy evacuated the fort in the course of the evening and escaped.

The Brigadier's force was employed for the rest of October in minor operations and ineffectual attempts to capture Dost Muhammad, who was then in the Nijrāo country. On the 19th October it was reinforced by the remaining six companies of 37th Native Infantry and two nine-pounders. On 29th October Sir Robert Sale was at Bāgh-i-Ālam, and there received intelligence that Dost Muhammad had left Nijrāo and come into the Kohistān valley. On 2nd November he approached the village of Parwan, and saw the enemy evacuating the forts and villages and flying to the hills.

The advanced guard under Lieut.-Col. Salter consisted of four companies of 13th Light Infantry, two of 37th, and one of 27th Native Infantry, two Horse Artillery guns, two squadrons of the 2nd Bengal Cavalry, and 200 of Anderson's Dūrāni Horse. The Cavalry pushed on to overtake the fugitives, and the 2nd Light Cavalry had preceded the column about a mile, when they were attacked by Dost Muhammad in person, at the head of about 200 horsemen, who rode down hill to attack them. The Cavalry was formed into line, and the charge ordered by Captain Fraser, who, with the other officers, rode on, believing that the men were behind them, but instead of that they went 'threes about' and fled. Lieutenant Crispin, the adjutant, with Lieutenant Broadfoot of the Engineers, and the political agent, Dr. Lord, were killed, Captains Fraser and Ponsonby severely wounded. The Infantry coming up recovered the lost ground, cleared the hill overlooking the Pass (or Dara) of Parwan, and the enemy fled towards the Panjsher valley. The result of the action was that Dost Muhammad, seeing the hopelessness of further resistance, rode in to Kābul next day and gave himself up to the Envoy, Sir William Macnaghten, whom he met returning from his evening ride. The force was recalled from the Kohistān, only a detachment of Gūrkhas being left to garrison Charīkar.

Sir Willoughby Cotton soon after this was relieved by General Elphinstone, and proceeded to India, escorted by the 1st Europeans and two companies of 27th Native Infantry and the 48th Native Infantry from Jalālābād. The 44th Regiment, under Colonel Shelton, replaced the 1st Europeans in Afghānistān. Dost Muhammad was sent with Sir Willoughby to Calcutta, where he was hospitably received by Lord Auckland, who assigned to him a pension of two lakhs of rupees.

The 1st Europeans had been in camp at Kaja during the hot weather of this year, a village about 30 miles from Jalālābād, under the Safed Koh, and there a trifling action took place under Lieut.-Col. Wheeler against some insubordinate Wazīris on 19th August.

We must now turn again to Balūchistān, where Nassir Khān had remained for some time master of the situation. He moved about the country, interrupting the communications with Kandahār and harassing the British posts. Wherever he went the unfortunate Lieutenant Loveday was invariably taken, carried about in a *kajāwa*, to which he was chained, and exposed, almost naked, to the burning heat of the climate.

Major-Gen. Nott, who was placed in charge of all military operations above the pass, moved from Kandahār on 9th September, and Major-Gen. Brookes, of the Bombay army, was placed in command of all the troops in Sindh. Nott was invested with concurrent political jurisdiction with Mr. Ross Bell, the chief political agent in Sindh.

General Nott took with him the four 18-pounders from Kandahār, and on 25th October reached Mastūng between Shālkot and Kalāt. The enemy had fled to the eastward, and on 29th, with between three and four thousand men, furiously attacked the British post at Dādar. Beaten off by the small garrison under Captain Watkins, of 23rd Bombay Native Infantry, they returned to the attack on 30th. But Major Boscawen of H.M.'s 40th, with the right wing of his own regiment, the 38th Bengal Native Infantry, 200 Sindh Horse, and two six-pounders, arrived the same day, whereupon the Khān fled, leaving on the ground the body of poor Loveday, whose throat had been cut by order of the Khān's minister, Gul Muhammad.

Meanwhile General Nott continued his advance on Kalāt with the 42nd and 43rd Native Infantry, the 18-pounders, some of the Shah's Infantry under Captain Macan, and Cavalry under Captain Walker, and a battery of the Shah's Horse Artillery.

Kalāt this time made no defence, the garrison fled, and General Nott occupied the place on 3rd November.

Nott left Colonel Stacey with the 42nd Native Infantry and 50 Horse to hold Kalāt, the Shah's 2nd Regiment and 50 Horse to hold Mastūng, and the Shah's 1st Regiment, six Horse Artillery guns, and a party of Cavalry, to aid in the defence of Shālkot. He returned himself to Kandahār on 14th December, with the 43rd Native Infantry.

Nassir Khān still continued in arms, but his camp near Kotra, 10 miles south-west of Gandāva, was surprised on 1st December by Lieut.-Col. Marshall, with 900 of Infantry detachments, 60 Irregular Horse, and two guns. Colonel Marshall attacked at daylight and completely surprised the enemy. Nassir Khān fled at the first alarm, but his chiefs and followers made a long resistance, and four of the chiefs with 500 men were left dead on the field. After this the Brahūis and Marrīs retired to their hills.

Thus, at the end of 1840, affairs in Afghānistān seemed in a fair way to be satisfactorily settled. The Balūchistān revolt had been put down, the line of communication with Kandahār fairly secured by the dispositions of General Nott, while in the north Dost Muhammad's resistance had been finally broken, and he himself was on his way to an honourable captivity in Calcutta.

Sir G. Lawrence says, 'the tranquillity which for the time prevailed in Afghānistān, the result of Dost Muhammad's surrender, was as remarkable as it was unprecedented. The wild tribes seemed suddenly to forget their old feuds and lawless habits, and to subside into peaceful subjects, while our European soldiers were able, for the first time since our arrival, to walk out in all directions for miles unarmed, with the most perfect safety.' The court spent the winter at Jalālābād, where Sir W. Macnaghten busied himself with schemes for the internal administration of the country. To India the political and commercial results of the two years' campaign are said to have been highly satisfactory. The Nepaulese drew in their horns; conspiracies in the Dakkan and Southern Mahratta country were discovered and crushed. The Burmese withdrew all manifestations of hostility. The Persians totally abandoned their designs upon Herāt and Afghānistān, and the Khivans yielded to our representations and conceded the demands of Russia. Large quantities of British Indian produce and manufactures, to the value of 38 lakhs of rupees, found their way into Afghānistān by the Indus and Panjāb, and there appeared every prospect of an extension of trade.

The only exception to the general tranquillity, and it was a serious one, at the beginning of 1841, was in the Dūrāni country, near Kandahār. When Shah Shūja reached Kandahār in 1839, the Dūrānis (glad to be freed from the oppressions of the Bārakzais) had rallied round the legitimate monarch, and their hopes were high as to their prospects under the restored dynasty. These hopes were disappointed, and in December they were up in arms in the Zamīn Dāwar, north-west of Kandahār, under a chief named Akhtar Khān. A detachment was sent out under Captain Farrington, which beat and dispersed the rebels near Shahrak, about 70 miles north-west of Kandahār, and for a time checked the spirit of rebellion. Captain Farrington also recaptured two guns which had been lost by a native force sent out during Major-Gen. Nott's absence by the political officer.

Kaye says, 'It was said and believed by many that Shah Shūja had secretly fomented the rebellion of the Dūrānis.' Ferrier, who was in Kandahār in 1845, says that, after the surrender of Dost Muhammad, Shah Shūja demanded, for the second time, the evacuation of the country, and that being refused, he intrigued against the British. M. Ferrier gives as causes of the dislike of the English their employment of Parsiwāns as officials, their not leaving the king to his own system of government, and the 'deplorable mania which the English have for scattering gold by handfuls.' The officers (he says) were prodigal in their expenditure, and that depreciated the value of money, thus reacting on the poorer natives. Again, the English paid for every species of labour tenfold what the Afghāns had ever received before, and even, he says, forced the Shah to pay his workmen at their rates. A further mistake we made was, constantly threatening to send some of the restless chiefs to India, 'and then not carrying out the menace.' Another cause of hatred was the connections formed with the women of the country, many of whom, Ferrier says, were legally married to British officers.

At the same time Yar Muhammad, the Wazir of Herāt, was doing all he could to stir up the Dūrāni country against the English, and had even proposed to the Persian Governor at Mashad to join him in an attack on Kandahār. His intrigues at last caused Major Todd, the Envoy at Herāt, to quit the court of Kamrān.

In January 1841 Brigadier Valiant's brigade consisting of two troops Horse Artillery, a nine-pounder Field Battery, two wings of Cavalry, the 40th Regiment, a wing of the 41st Regiment, two battalions of Bombay Native Infantry, the 20th and 21st, and a mass of irregular horse, marched from Sakkar (where it had arrived from Karāchi in December 1840) and proceeded to Mangal-ka-Shahr, near Bagh, where it remained for some time in camp. Whilst there, a small force with guns was sent to Kajak in the Sībī country, about 30 miles north-east of Dādar, under Colonel Wilson of the Bombay Cavalry, to coerce the Kākars of that place, but met with a disaster, two officers being killed and Colonel Wilson himself mortally wounded. The cause of this disaster was that the detachment was marched into the body of the town without taking possession of the houses right and left. The enemy waited till they had come in and then poured in a fire from under cover. A second attempt by dismounted Artillerymen under Lieutenant Creed was defeated owing to the want of support, and Lieutenant Creed himself was amongst the slain. The place was subsequently occupied and destroyed by the Brigadier.

Turning now to the north we find that in February of this year (1841) Colonel Shelton of the 44th conducted some operations in the Naziān valley, south of Pesh Bolak, in the Jalālābād country, to coerce a refractory tribe called Sangū Khel. Pesh Bolak, a village near Hazarnāo was held by Captain Ferris, with a corps of Jazailchis. Colonel Shelton moved from Jalālābād on the 21st February with his own regiment and the 27th Native Infantry, four Horse Artillery guns, and some other detachments, and on the 24th and 25th took about 80 of the small forts with which the Naziān valley was studded; not, however, without the loss of two valuable officers—Captain Douglas, A.Q.-M.G., and Lieutenant Pigou, of the Engineers. The latter officer was blown up while blowing open a gate, by the sudden explosion of a powder bag. It does not appear from the reports that the forts were demolished.

In this same month Akhtar Khān and the Dūrānis were again giving trouble in the Zamīn Dāwar, but on the approach of a force to Girishk, under Captain Woodburn, Akhtar Khān made his submission to Lieutenant Elliot, Major Rawlinson's assistant.

Meanwhile, General Nott, foreseeing the need of a larger force at Kandahār ordered up the troops in Shāl, and by the 1st March had seven regiments of Infantry, one of Cavalry, two troops of Horse Artillery, and one company of Foot Artillery at his immediate disposal. The 40th Regiment was at this time at Shālkot where it remained till October.

About the beginning of April the inhabitants of a small but strong fort near Kalāt-i-Ghilzai insulted Major Leech, who was Political Agent there. A force under Captain Macan, consisting of two corps of (Afghān ?) Infantry, 200 or 300 of Captain Christie's Cavalry and four guns, had been sent towards Kalāt-i-Ghilzai a short time before, and on their arrival moved out and captured the fort, killing the chief. This irritated the Ghilzais, who were still further incensed at the rebuilding of the fort of Kalāt-i-Ghilzai, which had been determined on by the Government with a view of keeping the surrounding country in order. They surrounded the place and attempted to obstruct the works. Lieutenant Wymer was sent from Kandahār with 400 men of the 38th Native Infantry, two Horse Artillery guns, a wing of the Shah's 1st Cavalry, and a small party of Sappers to reinforce Captain Macan. When in camp at Īlmī (20 miles from Kalāt-i-Ghilzai) he was attacked on 29th May, by not fewer than 5,000 Ghilzais. Having notice of their approach, Wymer received them with an accurate fire from his two six-pounders, whereupon they separated into three columns and came on sword in hand, but were greeted with a destructive fire from the musketry line. The action continued from 5 to 10 P.M., when the enemy were beaten off and dispersed, leaving 64 dead on the field. The 38th Native Infantry behaved with great steadiness, changing front and at one time ceasing to fire by order during the attack. Wymer's loss was small, four killed and 15 wounded. Next day he marched into Kalāt-i-Ghilzai, which was thus made secure from attack.

Whilst Wymer was operating in the direction of Kalāt-i-Ghilzai, General Nott learned that 400 of the armed population of Kandahār had left for the purpose of attacking him. He therefore felt little confidence in the fidelity of the people, and was anxious for the safety of the place. But he was soon called on for yet further detachments, for the Zamīn Dāwar was again in rebellion, and at the end of June Akhtar Khān was in arms before Girishk. Captain Woodburn was sent to the Halmand with his own corps, the 5th Shah's Infantry, some of the Shah's guns, and two detachments of Jānbāz, or Native Horse. He found the enemy on 3rd July posted on the right bank of the Halmand, but was unable to cross to attack. Later in the day the enemy, to the number of nearly 5,000, crossed by a ford three miles distant, and attacked, but were repulsed with loss. Woodburn could not follow up his success, as his Jānbāz would not fight. He pushed on to Girishk on the 5th, where he was reinforced in August by Captain Griffin with the Shah's 1st Regiment of Infantry, two guns, and a party of Cavalry. On 17th August Griffin defeated the rebels, headed by Akhtar Khān and Akram Khān, at Sikandarābād on the right bank of the Halmand. Prince Saftar Jang, son of Shah Shūja, distinguished himself in the pursuit, at the head of his own regiment of Jānbāz, who on this occasion behaved well. After this defeat the chiefs of Derawat and Tirin returned to their forts, lying in valleys opening to the Halmand some 70 miles north of Kandahār, and there they continued in open rebellion. General Nott was therefore ordered to prepare an expedition against them, which he proceeded to equip.

In the month of July, Nassir Khān of Kalāt came down from the hills and surrendered to Colonel Stacey at Kalāt. Mr. Ross Bell died and was succeeded by Major Outram as Political Agent in Upper Sindh. A trifling outbreak in the Kohistān was put down by Lieutenant Maule with his Afghān levies, and on the 5th August Colonel Chambers, with parts of 16th and 43rd Native Infantry and 5th Light Cavalry, obtained a success over the Ghilzais near Karūtā and the Sajāon Pass (north-east of Ghaznī) which caused that tribe to submit for the time.

By the beginning of September General Nott had completed his preparations for the Derawat expedition, and wrote on 7th to General Elphinstone, reporting the movement of the troops into camp. The force consisted of a company of Artillery with two 18-pounders, two of the Shah's Horse Artillery guns, a regiment of Shah's Cavalry, a detachment of Sappers, the 2nd and 38th Bombay Native Infantry, under Colonel Wymer. General Nott followed the force, and assumed command of it on 23rd September at Mīrān, in the Derawat. The chiefs and people did not attempt to make any opposition. They looked with dismay on our guns—though they had learnt by this time to despise our muskets—and they submitted. Akram Khān was surprised, made prisoner, and carried to Kandahār, where, in accordance with orders from Kābul, he was blown from a gun. Nott returned to Kandahār before the end of October.

The defeat of the Ghilzais in August, and of the Dūrānis in September, caused a lull, but one which was not destined to be of long continuance. The king was discontented with his position, and (according to Kaye) watched with satisfaction the difficulties of his allies. Ferrier goes much further, and says that towards the end of September the Shah *planned*, with Abdûlla Khān Achakzai, a revolt against the English, and the murder of Sir Alexander Burnes, whom the king detested on account of his having tried to support Dost Muhammad.

But probably even this combination would have been broken up had not the exigencies of the Indian exchequer (which was now becoming exhausted by the continued drain upon it) led to a measure which, more than any other, was calculated to excite hostility in Afghānistān. The inordinate love of money which characterises the Afghān has already been mentioned, and now it was determined to reduce the stipends of the Ghilzais, Kohistānis, Mohmands, and others who held the defiles through which lay the line of communication between Kābul and Peshāwar. At the commencement of October the Ghilzai sardārs were informed that they must submit to a reduction of 40,000 rupees. They immediately hastened to Kābul, and saw Sir W. Macnaghten, by whom they were referred to the king. The king dismissed them haughtily, but, according to Ferrier, received a few of them secretly, and took them into the conspiracy against the British. They immediately quitted Kābul, occupied the passes, and cut off the communication with Peshāwar.

The Shah sent Hamza Khān, governor of the Ghilzais, a man who was at the bottom of the whole conspiracy, on pretence of bringing the chiefs back to their allegiance. Of course nothing came of such a mission.

Sir Robert Sale was at this time about to proceed to India with his brigade on relief. To him was entrusted the task of clearing the passes. On 12th October Sale moved from Būtkhāk into the Khurd Kābul Pass. This defile has been already described as being merely the bed of a stream which flows north to join the Kābul river. It is about six miles in length. Sale had the 13th Light Infantry, 35th Native Infantry, and two field guns, some Sappers and some Jazailchis. He employed some Jazailchis, under Sardār Jān Fishān Khān, to crown the heights to the west, and then attacked the gorge, sending some skirmishers also to crown the heights on the left. The pass was forced with a loss of six killed and 33 wounded, the Brigadier among the latter. After reaching Khurd Kābul, the 13th returned to Būtkhāk, while the rest remained in camp at Khurd Kābul under Colonel Monteath. In these positions the force remained for nine days, till 22nd October, when Sale moved from Khurd Kābul with 13th Light

Infantry, 35th Native Infantry, and two companies of 37th, No. 6 Field Battery (camels), detachment of Sappers and Miners, a squadron of 5th Light Cavalry, and some of the Shah's Cavalry from Khurd Kābul to Tezīn. On this day he had to fight his way cautiously through the defiles of the Haft Kotal, occupying the hills on either flank with skirmishers, and, on reaching Tezīn, to capture a fort. The loss, however, was slight: one officer and four men killed, two officers and 17 men wounded.

At Tezīn a halt was made from 23rd to 26th, and on 27th the force marched to Kata Saug, and next day to Jagdalak, no opposition being met with in the Parī Dara. On the 29th October, during the march to Gandamak, there was a good deal of fighting in forcing the passage over the Kotal-i-Jagdalak. Companies were detached to the right and left of the road, to crown the heights, and, aided by the Artillery, were successful. In descending, the rear-guard was attacked, and Captain Wyndham of the 36th killed. The loss in this day was three officers and 37 men killed, four officers and 87 wounded.

At Gandamak, Sale halted from 30th October to 10th November, and while there received the news of the outbreak at Kābul and the murder of Sir Alexander Burnes, which occurred on 2nd November. Sale at first thought of returning to Kābul, but the loss of great part of his camp equipage, the number of his sick and wounded (300), and the want of any provision depôt on the road, or carriage to convey rations, rendered this plan impracticable. Whether he should not have remained at Gandamak, and fortified himself there—a place which is represented as fertile and well supplied—seems an open question. Be that as it may, he decided to occupy Jalālābād, and marched from Gandamak on 11th November, entering Jalālābād on 13th without any serious opposition. Arrived there he immediately proceeded to put the place in a state of defence.

Before relating the progress of events at Kābul, the outbreak in the Kohistān requires a short notice. Before the end of October the Kohistānis were in open revolt, and on 1st November Mīr Masjidī, one of the chief insurgents, took up a position at Āk-sarai, cutting the communications with Kābul. Major Pottinger, Political Agent, lived in the fort of Lagmani, about two miles from Charikar. At this place, which is the chief town of the district, and situated in a fertile valley, was stationed the Shah's Gūrkha regiment, commanded by Captain Codrington. On the 3rd November (that is to say, the day after Sir A. Burnes's murder), as Major Pottinger was receiving some *soi-disant* friendly chiefs in his garden, his assistant, Lieutenant Rattray, was treacherously murdered by them. Pottinger escaped into the fort.

where he was surrounded, but was soon relieved by Lieutenant Haughton, the adjutant of the Gūrkhas, from Charīkar. Codrington, who had been in the fort, and his men, returned to their barracks, leaving a small garrison with Major Pottinger, who joined them at Charīkar on the evening of the 4th.

The barracks at Charikar were unprovided with water, and were effectually commanded by the towers of a castle about 300 yards off, i.e. within range of jazails. It was therefore necessary to occupy that post, which was done with 50 men; but on 7th the garrison were induced, by the treachery of the regimental munshi, to surrender. The Gūrkhas in the barracks were now obliged to fight their way out for every drop of water they wanted. A few pools inside the fort were soon drunk up; on the 10th half a wineglass full was served out to every fighting man. Captain Codrington and Ensign Salisbury had been killed, and by 13th November the garrison was reduced to 200 fighting men, with only 30 rounds each. On the evening of the 13th November the Gūrkhas evacuated Charīkar. Pottinger and Haughton, both wounded, Haughton having lost a hand, Dr. Grant and Ensign Rose, were the remaining officers. Dr. Grant spiked the guns with his own hands, and led the main body, while Rose brought up the rear. Of all these only Pottinger and Haughton and one Gūrkha reached Kābul, though next year Haughton collected 165 Gūrkhas who escaped with their lives and were scattered about the country. The sick and wounded were of course all massacred, as well as the wives and children of the Gūrkhas, who had been brought up from India. Lieutenant Maule, commanding the Kohistāni regiment, and Lieutenant Wheeler, his adjutant, were also murdered at Kahdara on 3rd November. The regiment deserted and left the officers to be murdered by a party of the rebels. No relief of Charīkar was attempted from Kābul, though the distance is only 40 miles, over a tolerably open country, and Captain Colin Mackenzie volunteered to proceed with 200 men and convey ammunition. But, as we shall see presently, there was no enterprise now left among the chiefs of the Kābul garrison.

We now have to turn to the painful story of the destruction of the Kābul brigade. The position and nature of the cantonments I have already described, and it must be evident from the description of the place that if it had been deliberately desired to place a force in the worst possible position for defence it could hardly have been done more effectually than by the actual arrangements. Unfortunately there was little in the leading of the troops to compensate for the disadvantages of their position. General Elphinstone, who had relieved Sir Willoughby Cotton in April, was worn out and incapable, both bodily and mentally, and he was most unfortunate in his second in command, Brigadier Shelton, a man with an impracticable temper, though of distinguished personal courage.

On the 2nd November a tumult broke out in the city, the house of Sir Alexander Burnes (see Plate VI.) was attacked by the mob, and himself, with his brother, Lieutenant C. Burnes, of the Bombay army, and Lieutenant William Broadfoot, of the Bengal Engineers, murdered, and the treasury plundered. All accounts agree in stating that the outbreak was at first comparatively insignificant, that not more than 300 men attacked Burnes's house, and that a very moderate display of force and vigour on the part of the British authorities would have sufficed to put down the tumult in the city and avenge Sir Alexander's death. But nothing was done, and by the next day many chiefs, who had at first remained quiet, fearing the vengeance of the British, finding them inactive, ventured to join the insurrection, which now became general.

At the time of the outbreak the troops at Kābul were:—

Her Majesty's 44th.
54th Native Infantry.
5th ,, ,,
6th Shah's Infantry.
1 troop Horse Artillery.
Shah's 6-pounder Field Battery (5 guns).
3 Companies (Shah's) Sappers and Miners.
Detachment of Bengal Sappers and Miners.
5th Light Cavalry (2 squadrons).
5th Shah's Irregular Horse (Anderson's).
1 troop Skinner's Horse.
1 ,, 4th Irregular Horse.
The Envoy's Body Guard.

The 37th Native Infantry were in camp at Khurd Kābul, with half a mountain battery (three guns), and the total strength must have been about 5,500 men, with 14 guns, besides some heavier pieces mounted on cantonments and in the Bāla Hisār. Of this force the 44th Regiment, a wing 54th Native Infantry, the Shah's Infantry, and the Horse Artillery Battery were in camp at Siyāh Sang under Brigadier Shelton, and the rest in cantonments. On finding what was going on in the town Sir William Macnaghten requested General Elphinstone to garrison the Bāla Hisār, and accordingly Brigadier Shelton was sent from the Siyāh Sang camp with one company of 44th, a wing of the 54th Native Infantry, under Major Ewart, the 6th Shah's Infantry, and four Horse Artillery guns to the fortress, while the remainder of the troops in camp were brought into cantonments, and the 37th Native Infantry and the mountain guns were called in from Khurd Kābul.

On 3rd November the 37th Native Infantry came in with the mountain guns, and the garrison of the Bāla Hisār was then reinforced with the left wing of 54th, the three mountain guns, one iron nine-pounder, one 24-pounder howitzer, two of the mortars, and a supply of stores. Brigadier Shelton was ordered to open fire on the city and endeavour to fire it by means of shells and carcasses.

On the 4th November the first disaster occurred in the loss of the Commissariat Fort. The enemy on this day occupied the Shah Bāgh in force and put a garrison into the Fort of Muhammad Sharīf. The gate of the Commissariat Fort was on the side next the garden, and consequently this move on the part of the enemy at once put a stop to communication between cantonments and the stores of food. Upon this the General, instead of at once arranging to capture and hold the Shah Bāgh and the Fort of Muhammad Sharīf, actually ordered the evacuation of Commissariat Fort. On the remonstrance of Captain Boyd (the Commissariat officer) he sent counter orders, but Ensign Warren, who commanded in the fort, did not receive them. Several unsuccessful attempts were made to relieve the little garrison and take in fresh ammunition but they failed with considerable loss, including three officers killed and three wounded. At night the Envoy urged the General to capture Muhammad Sharīf's Fort, but hours were wasted in discussion, and before anything was done Ensign Warren and his party abandoned the fort and came into cantonments. Thus all the Commissariat supplies were lost and only two days' rations remained in cantonments.

The indignation of the garrison at the abandonment of the stores was extreme, and all were eager to recapture them. An attempt was made to storm Muhammad Sharīf's Fort, but it failed owing to the incapacity of the officer commanding the storming party. Next day, 6th November, the fort was breached and occupied, but the further necessary step of occupying the garden * was not taken, and though Lieutenant Vincent Eyre with a six-pounder gun drove the enemy out, no advantage was taken of the opportunity to seize the garden. At this time the Commissariat Fort had only been partially emptied, though the Afghāns were seen all the previous day carrying away provisions across the road into the cover of the garden. On the 8th November the want of provisions was felt. The Envoy could only obtain them by means of large bribes from the village of Bemarū, and even then there was only a scanty supply. On the 10th Brigadier Shelton was summoned from the Bāla Hisār. He brought with him the company of 44th, two guns, and the Shah's 6th Infantry. Shelton was sent for at the instance of Sir William Macnaghten in the hope that he would strengthen the hands of the General, but unfortunately

* Shah Bāgh, King's garden.

the result was otherwise. Shelton advocated an immediate retreat. The greatest despondency began to spread in the garrison, and the 44th Regiment in particular became very rapidly demoralised.

On this day the enemy occupied the Rikabāshi Fort, as well as the others on that side, and, at the instance of the Envoy, Brigadier Shelton was sent to storm it with the 44th, 37th Native Infantry, 6th Shah's Infantry, some horse and three guns. After some difficulty, owing to the blundering of the officer charged to blow in the gate, the place was taken, but with severe loss—200 killed and wounded—three officers (including Colonel Mackerell commanding 44th) being among the killed. After these officers had got inside with a few men a charge of Afghān horsemen round the fort caused a general flight, Europeans and Sepoys giving way together, and the fight was only restored by the courage and example of the Brigadier. Meanwhile those who had already got inside were cut to pieces except one officer and a Sepoy, who barricaded themselves in a stable, and had killed 30 of the enemy before they were rescued.

On the 13th November, there was an action on the Bemarū hills, where the enemy had appeared in force and fired with two guns into cantonments. At the earnest entreaty of the Envoy, Brigadier Shelton was sent out with four squadrons of Cavalry, two guns, and 16 companies to dislodge them. The musketry practice of the British seems to have been strangely bad. Eyre says that even at 10 or 12 yards it did little execution, so random was the fire. After some trouble the enemy were driven away and the guns taken, and one, a four-pounder, brought in. The other was spiked and abandoned, as the men of the 44th, in spite of the appeals of their commanding officer, would not drag it in, and their bad example was followed by the Sepoys.

This was the last success achieved, and afterwards, till the final destruction of the brigade, there is nothing but a sad list of blunders and disasters to record.

After this success, though the Afghāns did not venture to annoy the cantonments for some days, the weather became unusually severe, and the defects of the position more and more apparent. The propriety of a move to the Bāla Hisār, which had been recommended by Lieutenant Sturt, the garrison engineer, and others, was again discussed, and it seems clear that such a move was still practicable, although the military authorities were still against it.

The objections urged are given by Sir Vincent Eyre thus:—

(1) Difficulty of conveying sick and wounded.

(2) Want of firewood in Bāla Hisār.

(3) Want of forage for Cavalry.

(4) Moral effect of abandoning cantonments, and giving a triumph to the enemy.

(5) Risk of defeat on the road.

In reply it was urged that—

(1) Conveyance of sick, though difficult, was not impracticable.

(2) There was wood enough for cooking.

(3) The horses would be shot, as Cavalry would not be wanted.

(4) The supposed triumph would be short-lived, as everything not taken away would be destroyed.

(5) The distance was only two miles, one half of the distance protected by the guns of the Bāla Hisār, and the Siyāh Sang heights, if occupied, would have prevented the enemy impeding the movement.

Arrived at the Bāla Hisār, a small force would have secured the place, and a movable column would have been available for offensive purposes, and for collecting provisions and forage. But Brigadier Shelton had set his face against the movement. And so the force awaited its doom in cantonments.

On 18th November the capture of Muhammad Khān's Fort was decided on, but the idea was, later in the day, abandoned by the General.

On 22nd November a small force was sent to occupy the village of Bemarū, from which supplies were obtained and which was threatened by the enemy. The enterprise miscarried owing to the conduct of the same officer who caused the failure before Muhammad Sharif's Fort on the 5th. On this day Muhammad Akbar Khān, son of Dost Muhammad, arrived at Kābul.

Next day the enemy occupied the heights of Bemarū in force, and an action ensued in which the British were disastrously beaten. Brigadier Shelton was sent out to attack the enemy, with 17 companies of Infantry, 100 Sappers (to raise breastworks on the heights when captured), three squadrons of Cavalry, and a *single* Horse Artillery gun. The force gained the heights unperceived before daybreak, and the gun opened with grape on the village, surprising the enemy, but the chance of assault was missed, and a later attempt to storm the village miscarried from a mistake of the same officer who failed the day before. The force remained on the hill till after noon, when they were nearly surrounded by thousands of the enemy, and, besides losing many killed and wounded, became faint with fatigue and thirst. As if to leave nothing undone to procure disaster, the men were put into two squares on the hill, and so kept exposed to a hot fire of jazails, whilst the Cavalry was drawn up close to them in a dense mass, also under fire. At last the gun was lost, and the whole Infantry force fled to cantonments, suffering great loss, and was only saved from total destruction by a gallant charge of the Cavalry. Loss 178 killed and 55 wounded, besides that of the 5th Native Infantry, which is not known.

Next day Captain Conolly wrote from the Bāla Hisār to urge a retreat thither, but his proposal was met with the old objections.

After this there was no more attempt at military operations.

On 1st December an attack on the Bāla Hisār was driven off by Major Ewart. On the 5th the enemy completed the destruction of the bridge over the Kābul river (450 yards only from cantonments) at which they had been allowed to work unmolested since 24th November. On the 6th the garrison of Muhammad Sharīf's Fort (one company 44th and one of Sepoys) were seized with a panic, the Europeans leading the way, and fled. The enemy thereupon occupied the fort.

On the 11th, negotiations with the enemy were opened, and on the 13th the Bāla Hisār was evacuated under a treaty, which also provided for a safe conduct of the troops to India, and for provision of carriage.

Ten days later, on 23rd December, the Envoy was inveigled out to a conference, when he was murdered by Muhammad Akbar Khān. Though the spot where this occurred was scarcely 400 yards from the cantonments, no attempt at rescue or to avenge the deed was made, or apparently even thought of. The body was left lying on the plain, whence it was finally carried off, with every species of indignity, to the public market. It seems scarcely possible to conceive that a British army and British Generals could have become so demoralised and degraded as to remain inactive on such an occasion.

After the murder of the Envoy, Major Pottinger, though still disabled by the wound he had received at Charīkar, undertook, at General Elphinstone's request, the duties of the mission, and had to meet the chiefs in conference. One or two fresh conditions were imposed, the most important being that all the guns except six were to be given up.

On the 5th January 1842 a last attempt was made by Pottinger and Captain Lawrence to induce General Elphinstone to go into the Bāla Hisār, but he again declined.

On the 6th January, though neither of the terms as to transport or escort had been fulfilled by the Afghān chiefs, the retreat was commenced.

The strength of the Kābul force on leaving cantonments was:—

| | | |
|---|---|---|
| 1 troop of Horse Artillery | 90 | 690 Europeans. |
| H.M.'s 44th Foot | 600 | |
| 5th Light Cavalry (2 squadrons) | 260 | 970 Cavalry. |
| 5th Shah's Cavalry | 500 | |
| 1 troop Skinner's Horse | 70 | |
| Body Guard | 70 | |
| 5th Native Infantry | 700 | 2,840 |
| 37th " " | 600 | |
| 54th " " | 650 | |
| Shah's 6th Infantry | 600 | |
| Sappers | 20 | |
| Shah's Sappers and Miners | 240 | |
| Half mountain battery | 30 | |
| Total | | 4,500 fighting men. |

Besides these, the camp followers, at a very moderate computation, amounted to 12,000 men, besides women and children.

The force marched out in three columns, the advance led by Brigadier Anquetil, commanding the Shah's troops, the main column under Brigadier Shelton, and the rear-guard under Colonel Chambers; but the order was soon lost. The force contained no less than 1,340 of the Shah's own troops. The Shah had appealed to Brigadier Anquetil not to forsake him in his hour of need and deprive him of the aid of his own force, but no attention was paid to this remonstrance.

No sooner had the rear-guard left cantonments than the Afghāns manned the walls and opened fire. At Būtkhāk on the 8th, and again at Khurd Kābul on the 9th, General Elphinstone, believing the treacherous promises of Muhammad Akbar Khān, halted a whole day, and thus the last chances of escape were thrown away. The attacks of the enemy continued through the defiles of Khurd Kābul and the Parī Dara, until the last survivors perished at Gandamak on 13th January, Dr. Brydon alone escaping to report the disaster to Sale at Jalālābād on the evening of that day. The widows and married people, and the children still surviving on the 9th, escaped by having been given up to Muhammad Akbar Khān, at Khurd Kābul; and General Elphinstone, with Brigadier Shelton and Captain Johnson, were detained by the same chief, after a conference at Jagdalak on the 12th. General Elphinstone died in captivity on 25th April.

As an example of the tendency to sensational writing and over-colouring on the part of some of the writers on this disaster, it may be mentioned that Kaye represents Dr. Brydon as reporting his belief that he was the sole survivor of '*an army of some sixteen thousand men.*'

I have gone through the history of the destruction of Elphinstone's command in greater detail than the length of time at my disposal would warrant, were it not so important to make it clear that this great disaster was brought about from first to last by mismanagement on the part of both the civil and military authorities, which was nothing short of suicidal. I shall necessarily go much more rapidly over the other operations which I have to describe.

Returning to Sir Robert Sale, whom we left just entering Jalālābād on 13th November, we must now shortly review his famous defence. Full details of it may be read in Gleig's 'Sale's Brigade in Afghānistān.'

On reaching Jalālābād (*See* Plate VII.), Sale, whose force now consisted of about 1,600 men, with six guns,* found it in a quite indefensible state. The works had a total perimeter of 2,300 yards, and were in such a dilapidated state that Captain G. Broadfoot, his Engineer, had the greatest difficulty in making the circuit of the walls. The trace was bad, there was no parapet except for a few hundred yards, and that not more than two feet high, and the rampart was (owing to the accumulation of rubbish) everywhere accessible from without. At this time the Brigade had less than two days' provisions left, the inhabitants were disaffected, and there were 5,000 insurgents outside. Nevertheless, it was determined to occupy the place, and on 14th Colonel Monteath was sent to disperse the enemy.

On the 1st December Colonel Dennie routed the Afghāns, who had again appeared, and meanwhile the repair of the works went on. On the 9th January orders from Kābul were received to evacuate the place, under the terms of Macnaghten's treaty, but it was decided by a council of war not to obey, since it was known that Muhammad Akbar had sent to the chiefs in the neighbourhood to destroy the brigade on its retreat.

Early in January a brigade of four battalions, under Colonel Wild, reached Peshāwar with a convoy. On 15th January Colonel Moseley, with two of the regiments (the 53rd and 64th Native Infantry), was sent from Peshāwar to relieve Captain Mackeson and his Jazailchis at Ali Masjid, and to hold the post. By some neglect only a very small supply of provisions was sent up, so that on the 23rd Colonel Moseley had to return to Peshāwar, taking the garrison of the fort with him. In the meanwhile (on 19th January) Colonel Wild, with

* No. 6 Light Field Battery; 1 squadron 5th Light Cavalry; 1 troop Irregular Horse; 13th Light Infantry; 35th Native Infantry; Sappers and Miners.

the 30th and 60th Native Infantry and four guns lent by the Sikhs, made an ineffectual attempt to move from Peshāwar, taking supplies for Colonel Moseley, and with the intention of continuing his march to Jalālābād. But the Afrīdis had now risen and closed the pass, so that Wild, unable to force it, had to return to Jamrūd after considerable loss.

Discouraged by the failure of Colonel Wild, and under the belief that the Government were taking no steps to relieve Jalālābād, Sir R. Sale, on 26th January, called a council of war, to consider a letter received from Shah Shūja. Captain Broadfoot and two other officers stood out against surrender, but were overruled, and the negotiations continued. By 13th February, however, when the council met again to reply to further communications, Colonels Dennie and Monteath and Captain Abbott had changed their views, and the very next day the news of reinforcements moving up through the Panjāb reached Jalālābād. By this time the works were in a very satisfactory state, but on 19th February occurred a terrible earthquake, which shook down all their parapets, made a considerable breach in the rampart of the Peshāwar face, and reduced the Kābul gate to a heap of ruins.

Two days after the occurrence of the earthquake, Muhammad Akbar appeared before the place and attacked the foraging parties, and a few days later established a rigorous blockade. After that time, up to 6th April, the garrison had to be continually on the alert, but the Afghāns never ventured on an actual attack. On that day Muhammad Akbar Khān received a report that General Pollock (who had in reality forced the Khaibar Pass the day before) had been defeated, and he fired a salute in honour of the supposed victory. Sale determined to attack, and next morning led out his force, numbering under 1,500,* with Abbott's guns, against the Afghāns. Muhammad Akbar had drawn up his force, numbering nearly 6,000, in order of battle in a strong position, but he was speedily driven from it with severe loss, and his army entirely dispersed. Sale's loss was 11 killed and 71 wounded. Among the killed was the gallant Colonel Dennie, of 13th Light Infantry. Sir R. Sale had enlisted and trained his camp followers to the number of over 1,300, so that he was able to leave them in charge of the works, and move out almost every effective man of the brigade.

| | |
|---|---|
| * 13th Light Infantry | 500 |
| 35th Native Infantry | 500 |
| Sappers | 360 |
| 1½ Squadrons | 120 (?) |
| Total | 1,480 |

Whilst all this had been going on at Jalālābād and in Eastern Afghānistān, important events had been occurring at Kābul, at Kalāt-i-Ghilzai, and at Kandahār; but before describing them it is advisable to trace the first steps of Major-Gen. George Pollock, who, after the news of General Elphinstone's captivity reached the Governor-General, was appointed in January to the chief command.

General Pollock reached Peshāwar on 5th February, and found Colonel Wild's brigade not only much demoralised from its defeat and from communication with the Sikh soldiery, but also prostrated by sickness. Brigadier McCaskill, with a brigade consisting of the 9th Foot, 26th Native Infantry, the 10th Bengal Cavalry, and three guns, arrived two or three days later.

It was not till two months had elapsed that General Pollock found his force fit to advance. Besides labouring to improve the *morale* of the Sepoys, he had had to wait for Cavalry and Artillery.

At last, on 5th April, he was able to move, and he then proceeded to force the Khaibar Pass. His attack was conducted in three columns (*see* Appendix III.) by the upper, or Shādi Bajiarī road, while the Sikh auxiliaries took the lower road. Details of the operation may be found in Clery's 'Minor Tactics.' The right and left column moved on the heights right and left of the pass, and preceded the centre or main column, which only advanced against a breastwork at the entrance when it had been turned by the flanking columns. The Khaibarīs were beaten in every direction, and the force reached Ali Masjid, where it bivouacked for the night, with very little loss. The order of march is peculiar, in that every battalion was broken up. Thus the 9th, which had the honour of leading every one of the columns, was broken into six detachments, the 26th Native Infantry into three, and so on. Very precise orders were given to ensure the columns advancing equally, and signals arranged to regulate the advance. The total loss in killed and wounded was 135. General Pollock reached Jalālābād on 16th April, where the band of the 13th Light Infantry 'played him in' to the tune of 'Oh, but ye've been lang o' coming.'

Leaving General Pollock at Jalālābād, where he was detained for four months, we turn to General Nott's proceedings in Western Afghānistān, first noticing on the way the death of Shah Shūja, who was murdered at Kābul on 6th April, and his son Fateh Jang placed in his stead. At the end of October the first British regiment which joined General Nott's command came up, the 40th, a remarkably fine and efficient battalion. In November the force at his disposal consisted of six regular battalions,* a battery of Bombay Artillery, a troop of

* 40th Regt., 2nd N.I., 16th N.I., 38th N.I., 42nd N.I., and 43rd N.I.

the Shah's Horse Artillery, some regiments* of Shah's Infantry, and detachments of the Shah's and Skinner's Horse. Out of these Lieut.-Col. Maclaren's Brigade, the 16th, 42nd, and 43rd Native Infantry, were under orders to return to India. The brigade marched on 7th November, but was immediately recalled, in consequence of disturbances in the Ghilzai country, Captain Woodburn and a party of 130 men having been treacherously massacred on the road to Kābul in a friendly fort. On 17th November it marched for Kābul, in compliance with the demand made by Sir William Macnaghten. The brigade did not get far beyond Kalāt-i-Ghilzai. Its despatch had been against the judgment of the General, and he was very glad to see it back. But it seems that the difficulties it met with in the way of snow and loss of cattle were scarcely such as to justify its retreat; and as it had reached a point only four marches from Ghaznī, it became afterwards a subject of regret that it did not at least relieve that place. The brigade reached Kandahār on its return on the 8th December, having on its way reinforced the garrison of Kalāt-i-Ghilzai with 300 men of the 43rd Native Infantry, thus bringing it up to 900 Infantry with 40 European Artillerymen.

Ghaznī was held at this time by the 27th Native Infantry, under Colonel Palmer; the defences had not been put in order, neither was the garrison properly provided, either with provisions or stores, and there were no Artillerymen. They occupied the town, which was much too extensive for their force to hold. On 20th November the place was surrounded, and though the news of Maclaren's approach caused the enemy to break up their camp, they returned on 7th December, and about the 15th were admitted into the town by the inhabitants, the garrison being forced to retire to the citadel. There they suffered greatly from cold, frostbites, and want of food and firing, the thermometer going down on Christmas Day to 14°. About the middle of January a truce was made, and Colonel Palmer agreed to evacuate the place on the arrival of an officer from Shah Shūja to take it over.

On various pretexts Colonel Palmer delayed the surrender after the arrival of the chief in February, but had to march out of the citadel with his remaining force (about 450 men) on 6th March. Colonel Palmer appears to have wanted force of character, and to have failed to make arrangements which might have secured a supply of water and provisions. Many of the Sepoys and some officers were murdered and all shamefully treated by the Afghāns.

Early in January a large force of Afghāns, under Prince Suftar Jang† and Atta Muhammad, assembled near Kandahār, but they were

* Number not known. † Who had deserted from Kandahār.

beaten and dispersed by General Nott on 12th January. In spite of this the Dūrānis soon reassembled in force, and from 20th January to the end of February encamped near Kandahār, while, owing to the severity of the season, no operations were undertaken against them.

Not until the 21st February did the orders for evacuation of Kandahār and Kalāt-i-Ghilzai under Macnaghten's treaty reach Kandahār. General Nott, like General Sale, refused to act upon them. Meanwhile provisions for five months had been collected, the fortifications of the town repaired, and steps taken to disarm the inhabitants. The General was ably seconded by the Political Agent, Major Rawlinson, who now made arrangements to expel the Afghān inhabitants. About 1,000 families (all the suspected inhabitants) were driven out, and their exodus was complete by 6th March. Next day the General took the field with the bulk of his force, leaving Major Lane, of the 2nd Native Infantry to hold the city, with about 2,500 men. The enemy were driven first across the Tarnak and then over the Argand-āb, but, owing to his want of sufficient Cavalry and the reduced condition of what he had (from want of good forage), the General was not able to inflict very serious loss, and the enemy doubled back towards Kandahār in the hope of surprising the place. On the night of the 10th the Herāt gate was fired by a stratagem, and a desperate attempt made to storm it. But the garrison opposed a steady resistance and made a barricade of flour bags inside the blazing gate, so that though it fell outwards the enemy were unable to effect an entrance. Attempts to fire the Shikārpur and Kābul gates failed.

On the 25th, and again on 26th, sorties were made under Colonel Wymer and General Nott, after which Kandahār was left unmolested for some time. Early in March Major-General England, who had succeeded General Brookes in command of the Sindh field force, marched from Dādar to join General Nott. His force comprised the 41st Regiment, the 6th, 20th, and 25th Bombay Native Infantry, a battery of Horse Artillery, a company and a half of European Artillery and some Cavalry. Of these he was to leave two Native Infantry regiments and half a company of Artillery at Shālkot, and take the rest and a convoy of ammunition, money, and medicines to Kandahār. He moved on 28th March to Haikalzai with only part of his force—11 companies, a troop of Cavalry, and four guns. There he was unexpectedly opposed, and fell back with a loss of 100 killed and wounded. He then began to entrench the cantonments at Shālkot, and wrote on 10th April to General Nott that the works there would require so large a force to defend them as to render his advance hazardous, but that he would make a diversion to favour General Nott's *retirement*. General Nott replied, pointing out that it was wrong to entrench 'that straggling and wretched cantonment,' when the town with its citadel could answer every purpose with a garrison of 500 men. Nott added that he had no intention of falling back, and desired England to have his brigade at the Khojak by the 1st May to effect a junction with a brigade from Kandahār, and accompany it on its return. He stated from his own knowledge that there was no difficulty in crossing the Khojak Pass 'provided the heights on either side are properly crowned.' After this forcible appeal General England could hesitate no longer; he moved on 26th April, much to the surprise of his officers, who were settling down into cantonments; was again at Haikalzai on the 28th, where the enemy were easily beaten. On 30th April he reached the Khojak, through which a passage was cleared for his brigade by Colonel Wymer, sent from Kandahār, with the 2nd, 16th, and 38th Native Infantry, a troop of Horse Artillery and some Cavalry. Colonel Stacey mentions that the heights were so steep that it was impossible to climb them in pantaloons (I believe in those days the native army was dressed exactly like the Europeans), and so the Sepoys fought in their dhotis. On the 10th May the combined brigades reached Kandahār.

General Nott was now eager to advance on Kābul and join hands with General Pollock, who for his part was pressing to be allowed to advance. But for some time Lord Ellenborough, who had come out with a peace policy to succeed Lord Auckland, was bent on withdrawal. General Nott made every exertion to procure camels for his force, and meanwhile sent Colonel Wymer off, on 19th May, with a brigade* to relieve Kalāt-i-Ghilzai. The garrison of that place, after being reinforced in December by Colonel MacLaren, was unmolested for some months, the severity of the winter, the temperature 8° below zero and high north wind always blowing, though it caused great hardships to the garrison, also keeping away the enemy. With the spring the Ghilzais reappeared and by the beginning of May closely invested the place. Colonel Wymer reached Kalāt-i-Ghilzai on 26th May, but on the 20th the Ghilzais had assaulted the place and been gallantly defeated by the garrison. The enemy in this siege showed some knowledge of attack, for they dug trenches round the place in the night (the nearest within 250 yards) and loopholed them so as to give perfect cover. Their jazails (effective up to 600 yards) enabled them to annoy with impunity the garrison armed only with the musket. They were seen through telescopes practising escalading, and

* 40th Regt., 2nd N.I., 16th N.I., 38th N.I., 10 guns, and about 600 Cavalry.

they succeeded with their ladders in crossing the ditch, ascending the escarp, and actually planting a standard within a yard of the muzzle of one of the guns. The garrison was formed, as already stated, by detachments of 43rd Native Infantry, the Shah's 3rd Infantry and 40 European Artillerymen. The Shah's regiment was afterwards taken into the Company's service, and is now the 12th Native Infantry, still known as the Kalāt-i-Ghilzais.

Colonel Wymer brought off the garrison and reached Kandahār on 7th June. While he was absent, Akhtar Khān, of Zamīn Dāwar, had again appeared before Kandahār and been defeated by General Nott on 29th May.

I have now brought my narrative down to the time when both General Pollock and General Nott had a powerful force concentrated at their immediate disposal, all burning to advance and avenge the massacre of their countrymen. But for a while the views of the Governor-General were limited to procuring by negotiation the release of the prisoners, and then withdrawing. It was not till 4th July that Lord Ellenborough wrote to General Nott a despatch (which will be found in the Second Volume of 'The Life of Sir William Nott') authorising him to move by Kābul to Jalālābād. This letter, when read *in extenso*, does not appear to warrant the censure passed on it by Kaye, who gives only his own version of it. He calls it a masterpiece of Jesuitical cunning, and likens the movement to that of a man wishing to retire from London to Reigate, taking Dover and Canterbury on the way. Lord Ellenborough did not then contemplate the necessity of General Pollock's moving actually to Kābul, as he held General Nott's force 'amply sufficient to beat anything the Afghāns can oppose to it.' General Pollock was to be instructed by a forward movement to favour General Nott's advance.

On 8th August General Nott moved from Kandahār with seven battalions, about six squadrons of Horse, and 22 guns.* He sent Major-Gen. England with the rest of the troops † to Sindh, with

* GENERAL NOTT'S FORCE:—

| | |
|---|---|
| H.M.'s 40th Regiment. | 1 troop Bombay European Horse Arty. |
| " 41st " | 1 troop Shah's Horse Artillery. |
| 2nd Bengal Native Infantry. | 1 9-pounder Field Battery. |
| 16th " " | 1 company Bengal Artillery, with four 18-pounder guns. |
| 38th " " | 3rd Bombay Light Cavalry. |
| 42nd " " | Haldane's and Christie's Horse. |
| 43rd " " | |

† MAJOR-GENERAL ENGLAND'S COLUMN:—

| | |
|---|---|
| One troop Horse Artillery. | 25th Bombay Native Infantry. |
| Bullock battery. | Some companies of a Light Battalion. |
| A detachment Pūna Horse. | Three battalions Shah's Infantry. |
| Two Risālas Irregular Cavalry. | |

orders to withdraw the garrisons of Shālkot and Kala Abdullah on his way.

General Nott met with no opposition until he reached Kala Azīm, a march beyond Mūkūr. At this place, on 28th August, an unfortunate Cavalry affair occurred, in which his small force, having got under a fire of jazails, were beaten by the Afghān Horse, losing two European officers killed and 56 men killed and wounded.

On 30th August he encountered the Afghān commander Shamsh-ud-dīn Khān at Kārābāgh, near Ghoain, about 35 miles from Ghaznī. The Afghāns were about 12,000, and came boldly on to the attack, but were soon defeated with the loss of guns, tents, and ammunition. The want of Cavalry to follow up the victory was much felt on this day. General Nott halted at Ghoain on 31st to restock his commissariat from stores found there, and, resuming his march on 1st September, arrived before Ghaznī on 5th. Siege works were begun the same night, the intention being to breach the wall connecting the citadel with the town from a battery on the heights of Balol. On the morning of the 6th, however, it was found that Shamsh-ud-dīn and the garrison had fled. On the 7th and 8th the Engineers were busy destroying the walls of the citadel and demolishing the gateways of the city. The great gun called Jabbar Jang was also blown to pieces. The General here had the satisfaction of recovering a considerable number (327) of the Sepoys of the 27th Native Infantry, belonging to Colonel Palmer's garrison, who had been sold into slavery. The officers had been taken away to join the prisoners belonging to the Kābul force.

On 10th September, General Nott resumed his advance, taking with him the famous gates of Samnāth, which were removed by order of the Governor-General from the tomb of Sultān Mahmūd, who carried them away from India in A.D. 1020. Lord Ellenborough intended to restore them to their original place, but they never got beyond Āgra, where they are still to be seen.

At Beni-badām on 13th, and Maidān on 14th, General Nott again experienced considerable resistance, which was gallantly overcome by his troops, and on the 17th September he encamped his force in the beautiful plain west of Kābul.

But General Pollock had reached Kābul before him.

On the 4th July the Governor-General in forwarding to Major-General Pollock a copy of his letter to Major-General Nott, added: 'You will endeavour to combine your movements, as far as you can, with those of the Major-General, should he decide on adopting the line of retirement by Ghaznī and Kābul.'

Availing himself of this tardy permission of the Government, and finding that his negotiations with Akbar Khān for the release of the prisoners must fail, owing to the chief imposing the impossible condition that his army must first evacuate Afghānistān, General Pollock, to the great delight of his whole force, moved from Jalālābād.

Sir R. Sale was in camp with his brigade at Fatehābād, to which place General Pollock sent the 3rd Light Dragoons (now Hussars) and some Artillery to join him. Leaving a sufficient garrison at Jalālābād with the sick, and most of the baggage, he marched to Sultānpūr on 20th August. The force he took with him to Kābul amounted to 8,000 men with 17 guns. This force was organised in two divisions; Major-General Sale commanded the 1st Division and the 1st Brigade; Brigadier Tulloch the 2nd Brigade; Major-General McCaskill commanded the 2nd Division, with Brigadier Monteath under his orders. Colonel White, of the 3rd Light Dragoons, commanded the Cavalry.

1st DIVISION.

Sale { 13th Light Infantry. / 35th N.I. }  Tulloch { 9th Foot. / 26th N.I. }

3rd Light Dragoons.
1st Light Cavalry (1 squadron).
3rd Irregular Horse (1½ squadrons).

| | | |
|---|---|---|
| 2 | 3rd troop 1st Brigade Horse Artillery. | |
| 6 | No. 6 Field Battery. | Sappers and Miners, 5th Company. |
| 3 | Mountain guns. | Broadfoot's Sappers. |
| | | Mackeson's Beldars. |
| 11 | guns. | |

2nd DIVISION.

31st Foot.
33rd N.I.
60th N.I.

| | | |
|---|---|---|
| 1st Light Cavalry (2 squadrons). | 3rd Troop, 1st Brigade H.A. | 2 |
| 3rd Irregulars (1½ squadrons). | 3rd " 2nd " | 2 |
| | | 4 guns. |

A Sikh contingent of 500 horse and foot and 5 guns.

On 24th the General was at Gandamak, where the force assembled, and on 25th attacked the neighbouring fortified villages of Mamu Khel and Kuchli Khel, the inhabitants of which had been foolish enough to assume a threatening attitude. At Gandamak General Pollock halted till 7th September, for the Commissariat to bring up supplies and also in order to receive further news of General Nott. He had not had any communication from that officer of a later date than 27th July till late on 6th September, when news of the movement from Kandahār arrived. Next morning he marched to Surkh-ab with Sale's Division. A considerable detachment had to be left at Gandamak, owing to the want of baggage cattle, and to protect a depôt of stores formed there. It comprised :—

| | | |
|---|---|---|
| 33rd N.I. | Left wing of each, from 2nd Division. | 1 squadron 5th Light Cavalry. |
| 60th N.I. | | 1 „ 10th „ |

2 guns, 3rd Troop 2nd Brigade Horse Artillery.

An entrenched camp was formed in a good position easily capable of defence. Major-General McCaskill's division marched from Gandamak one day after General Pollock. On the 8th General Pollock marched from Surkh-āb and found the enemy strongly posted on the Kotil-i-Jagdalak. After ineffectually trying to drive the enemy away by artillery fire the General formed three columns of attack: one moved against either flank and the third against the centre. The Ghilzais did not wait for the bayonet, but fled when our troops had scaled the heights. The General rapidly pushed his advance and reached Kata Sang the next day, thus doing 20 miles through this terribly difficult country in two days, besides fighting.

On the 10th he reached Seh or Isah Bāba, and on the 11th moved to Tezīn, where he was joined by the 2nd Division which had met with no resistance, owing to its having crowned the heights with parties which again joined the rear-guard as it passed. From Tezīn he would have marched on the 12th, but the cattle of General McCaskill's division had suffered so much from their long and difficult forced march on the 11th that he was obliged to halt for a day.

Muhammad Akbar Khān, on finding General Pollock's army was approaching Kābul, sent away his captives from the Fort of Ali Muhammad near Kābul (where they had latterly been living in comparative ease) to the Hindū Kūsh, and himself left Kābul, intending to oppose the General's advance at Khurd Kābul. Encouraged, however, by what he thought the General's indecision in halting on the 12th, he attacked the British picquets in the afternoon and, though the attack was repulsed by Lieut.-Col. Taylor and part of the 9th Foot, the Afghāns continued to annoy the outposts throughout the night. Next day, when General Pollock advanced to the entrance of the Tezīn Pass he found Muhammad Akbar strongly posted there with a force of about 16,000 men. The 13th Light Infantry were sent to mount the heights on the right, the 9th and 31st on the left. The General says the Afghāns 'fought really well, actually coming up to the European bayonets.' Infuriated by the sight of the remains of their comrades who had been massacred on the ground a few months before, neither European nor Sepoy thought of giving quarter, and the loss of the enemy was severe. Early in the day the Cavalry had a chance of distinction. The enemy's horse entered the valley to attack the baggage and were successfully charged by Captain Unett's squadron of 3rd Light Dragoons and a squadron of the 1st Light Cavalry, Major Lockwood's squadron of the 3rd being kept in hand as support.

After being completely driven from the Tezīn Pass the Afghāns retired to the Haft Kotil, from whence also they were driven in confusion. The British loss on 12th and 13th was 33 killed and 130 wounded, while the enemy were completely broken up, lost several hundred killed, and were so much demoralised as to be unable to offer any further resistance.

On the 14th General Pollock traversed the Khurd Kābul Pass (not without the precaution of sending parties to crown the heights) and encamped at Būtkhāk. On the road the skeletons of those massacred in January were so thick on the ground (says General Pollock in a letter to his brother, Sir Frederick) that our men were obliged to drag them to one side to allow the gun carriages to pass. On the 15th General Pollock's force encamped on the Kābul racecourse, and two days later, as we have already seen, General Nott's force arrived on the same plain. General Pollock, immediately on reaching Kābul, despatched Sir Richmond Shakespear, with 600 Kazlbāsh horsemen, to the rescue of the prisoners whom he met on the 17th. They had had a very narrow escape of being carried off into Turkistān, but succeeded in bribing their keeper (one Sāleh Muhammad Khān) to deliver them. On the 21st they were all (except Captain Bygrave, who was subsequently set at liberty by Akbar Khān) safe in the British camp. A large number of people from Kābul had taken refuge at Istālif and many of the chiefs having also fled thither it was necessary to break up a confederacy formed by Amīr Ullah Khān, in order to prevent his attacking the flank of the line of march on leaving Kābul. General McCaskill was sent with a combined force to scatter the enemy at Istālif and destroy the place. This he effected on 29th September, and before returning also destroyed Charīkar, where the Gūrkhas had been massacred.

It was decided to spare the Bāla Hisār, in order to have a suitable residence for Prince Shāhpur, who was now to ascend the throne instead of Fateh Jang, Fateh Jang having no wish to retain it without British support. The great bazaar, in which the corpse of Sir W. Macnaghten had been exposed to insult, was therefore selected for destruction as a mark of British vengeance for the murder, and was blown up by the Engineers.

On the 12th October the British army broke up from Kābul, and General Pollock reached Peshāwar on the 2nd November, having destroyed the fortifications of Jalālābād on the way.

General Nott's force arrived two or three days later. Throughout the retreat General Pollock invariably made the most careful arrangements for flanking parties, and so complete were his precautions that he reached Jalālābād without a single casualty, and lost only two or three men and no baggage in the Khaibar. In his despatch to Government he says he crowned the heights the whole way and had a strong rear-guard. Generals Nott and McCaskill, who were less scrupulously careful, were not so fortunate, but suffered some loss.

From Peshāwar the combined force marched through the Panjāb to Fīrozpūr, where the Governor-General, surrounded by the army of reserve, was in camp to receive it. The year was closed with a grand military display. The plain was covered with British and Sikh troops, and in the presence of the Partāb Singh, the heir-apparent of Lahore, and the Governor-General, some forty thousand men with a hundred guns were manœuvred on the great plain. On this grand tableau the curtain fell; and the year, begun so darkly in the beleaguered cantonments of Kābul, 'closed (says Sir John Kaye) in gaiety and glitter, in prosperity and parade.'

H. H. J.

# APPENDIX I.

## DETAIL OF THE ARMY OF THE INDUS.

Gen. Sir HENRY FANE, G.C.B., Com.-in-Chief in India . . Commander-in-Chief.

| | |
|---|---|
| Major P. Craigie . . . . . | D.A.G. |
| Major W. Garden . . . . . | D.Q.-M.G. |
| Major-Gen. J. Thackwell, K.H. . . | Commanding Cavalry. |
| Brig. Stevenson, Bombay Artillery . . | Commanding Artillery. |
| Capt. G. Thomson . . . . . | Chief Engineer. |

### BENGAL COLUMN.

| | |
|---|---|
| Cavalry Brigade.<br>Col. Arnold, 16th Lancers—Brigr. | 16th Lancers.<br>2nd Light Cavalry.<br>3rd Light Cavalry.<br>4th Local Horse,<br>and<br>Det. Skinner's Horse. |
| Artillery.<br>Brigr. Graham. | 2nd Troop, 2nd Brigade, H.A.—Capt. C. Grant.<br>4th Comp., 2nd Bn., Ben. A.—Capt. Garbett.<br>Camel Battery—Capt. A. Abbott. |

### (BENGAL) INFANTRY DIVISION.

Major-Gen. Sir WY. COTTON, K.C.B., K.C.H.

(Capt. HAVELOCK, 13th Light Infantry, one of A.D.C.)

| | | | |
|---|---|---|---|
| 1st Brigade.<br>Col. Sale, 13th. | 13th Light Infantry.<br>16th Native ,,<br>48th ,, ,, | 4th Brigade.<br>Lt.-Col. Roberts,<br>1st Europeans. | 1st Europeans.<br>35th Native Infantry.<br>37th ,, ,, |
| 2nd Brigade.<br>Maj.-Gen. Nott. | 31st Native Infantry.<br>42nd ,, ,,<br>43rd ,, ,, | Bengal Sappers and Miners<br>(Two companies). | |

### RESERVE FORCE AT FĪROZPŪR.

Major-Gen. DUNCAN.

| | | | |
|---|---|---|---|
| Artillery | 3rd Troop, 2nd By., H.A.<br>3rd Co., 2nd Bengal Art.<br>(12 guns and 200 men). | Cavalry | Skinner's<br>Local Horse<br>(600 men). |
| 3rd Infantry Brigade.<br>Col. Dennie. | 3rd Buffs.<br>2nd N.I.<br>27th N.I. | 5th Infantry Brigade.<br>Col. Worsley. | 5th N.I.<br>20th N.I.<br>53rd N.I. |

## BOMBAY COLUMN.

Lieut.-Gen. Sir JOHN KEANE, K.C.B. and G.C.B.

(Capt. OUTRAM, extra A.D.C.)

| | |
|---|---|
| Major Keith . . D.A.G. | Commanding Artillery. |
| Major N. Campbell . D.Q.-M.G. | Capt. Peat . Chief Engineer. |
| Cavalry Brigade. Lieut.-Col. J. Scott, 4th Light Dragoons. | Wing 4th Light Dragoons.<br>1st Light Cavalry.<br>Pūnah Local Horse, unattached. |
| Artillery. Lieut.-Col. Stevenson. | 3rd Troop H.A., Capt. Martin.<br>4th „ „ „ Cotgrave.<br>Horse Field Baty. „ Lloyd. |

INFANTRY DIVISION.

Major-Gen. WILLSHIRE, C.B.

| | |
|---|---|
| 2nd Queen's. | 1st Grenadier N.I. |
| 17th Regiment. | 5th N.I. |
| 19th N.I. | 23rd N.I. |
| Siege Guns | Two 18-pounders.<br>Four 9 „ |

## RESERVE AT KARĀCHĪ (BOMBAY TROOPS).

Brigr. VALIANT.

| | |
|---|---|
| Artillery: 3rd Comp., 1st Bn. Art.<br>5th Golandaz By. (200 men). | Infantry: 40th Regt.<br>2nd Grenadiers.<br>22nd N.I.<br>26th N.I. |
| Pioneers . 100 men. | |

## STRENGTH OF THE DIFFERENT CORPS, &c., ON MARCHING INTO AFGHANISTAN.

| | BENGAL. | | BOMBAY. | |
|---|---|---|---|---|
| Park | Mortars, 8-inch | 2 | | |
| | „ 5½ „ | 2 | | |
| | Howitzers, 24-prs. | 1 | | |
| | „ 12-prs. | — | | |
| | Guns, 18-prs. | 4* | | 2 |
| | „ 9-prs. | 2 | | |
| | Field Guns, 6-prs. | 2 | | 4 |
| | Guns | 13 | Guns | 6 |
| Field Artillery | 1 Tr., 5 6-pr. and 1 how. | 6 | 2 Troops | 12 |
| | 1 Co. Ft., do. do. | 6 | 2 Fd. Batteries (one of these, drawn by mules, was left at Quettah) | 12 |
| | Camel Battery, 9-prs. | 6 | | |
| | Guns | 18 | Guns | 24 |

* These were taken to Kandahār and left there.

STRENGTH OF THE DIFFERENT CORPS, &c., ON MARCHING INTO AFGHĀNISTĀN (*Continued*).

| BENGAL. | | BOMBAY. | |
|---|---|---|---|
| Artillery—Horse and Foot | 200 | | 400 |
| Cavalry—Europn.—16th Lancers | 480 | Wing, 4th Light Dragoons | 300 |
| Cavalry—2 N.C. regiments | 950 | 1 Native regiment | 500 |
| Cavalry—Local H. & detachmts. | 1,000 | Local Horse | 400 |
| Infantry—2 European battalions | 1,080 | 2 European battalions | 1,080 |
| Infantry—7 N.I. do. | 5,000 | 4 Native do. | 3,000 |
| Sappers and Miners—Native | 250 | Sappers and Miners | 100 |
| Pioneers | 240 | Pioneers | 100 |
| Men | 9,200 | Men | 5,880 |

## SHAH SHŪJA-UL-MULKH'S FORCE.

6,070 Men.

Major-Gen. F. H. SIMPSON.

Cavalry Brigade. Capt. Christie, 3rd B. Cav. — 1st Regt. Cavalry, 2nd „ „

Artillery. Capt. W. Anderson, Beng. H.A. — 1st Troop, 2nd „

| Infantry Brigade (5 battalions) | | |
|---|---|---|
| | 1st Regt. | Capt. Beau. |
| | 2nd „ | „ Macan. |
| | 3rd „ | „ Craigie. |
| | 4th Light Infantry | „ Hay. |
| | 5th Regt. | „ Woodburn. |

## SHAHZĀDA TAIMŪR'S FORCE.

Under Lieut.-Col. WADE.

Artillery — 2 24-pounder howitzers and 2 6-pounders, with 20 swivels, under Lieut. Maule, Bengal Artillery.

Cavalry — 1,000 Musalmāns, armed with swords, shields, and matchlocks.

| Infantry | | | |
|---|---|---|---|
| Regulars | 3 battalions | 2,040 men | With 4 companies of British Native Infantry (320 men). |
| Irregulars | 1 battalion | 820 „ | |
| Jazailchis | | 320 „ | |

Making the total of Taimūr's force about 4,500 men of all sorts, with four guns.

## RANJĪT SINGH'S CONTINGENT

consisted of

| | |
|---|---|
| 12 guns | with 100 men. |
| Infantry | 4,800 |
| Cavalry | 1,050 |
| | About 6,000 men. |

1 howitzer. 1 mortar. 8 6-pounders. 2 9-pounders.

## THE SIKH CONTINGENT

was also under Col. WADE's direction, who therefore disposed of 10,500 men, with 16 guns of various descriptions.

## SUMMARY OF AVAILABLE TROOPS BEFORE THE REDUCTION OF THE FORCE.

| | |
|---|---|
| Bengal Column | 9,500 |
| Reserve at Fīrozpūr | 4,250 |
| Shah Shūja's Contingent | 6,000 |
| The Bombay Column | 5,800 |
| Bombay Reserve at Karāchī | 3.000 |
| | 28,550 |
| The Shahzāda Taimūr's force | 4,800 |
| Sikh Contingent | 6,000 |
| | 10,800 |
| Sikh Army of Observation at Peshāwar | 15,000 |

# APPENDIX II.

## DISTRIBUTION OF BRITISH FORCE IN AFGHANISTAN.

OCTOBER 1839.

| | |
|---|---|
| Kābul.<br>Lieut.-Col. Dennie. | No. 6 Field Battery, 3 guns.<br>13th Light Infantry.<br>35th N.I.<br>Shah's 1st Cavalry.<br>Some Artillery. |
| Jalālābād.<br>Lieut.-Col. Roberts. | No. 6 Field Battery, 3 guns.<br>2nd Light Cavalry.<br>1st Europeans.<br>37th N.I.<br>48th N.I.<br>Detachment Sappers and Miners.<br>Skinner's Horse, 1 Risāla. |
| Ghaznī.<br>Major MacLaren. | 16th N.I.<br>Skinner's Horse, 1 Risāla. |
| Kandahār.<br>Major-Gen. Nott. | 4th Company, 2nd Brigade, Artillery.<br>42nd N.I.<br>43rd N.I. |
| Dādar. | 4th Local Horse, 1 Risāla.<br>31st N.I.<br>4th Local Horse, 2 Risāla. |
| Sakkar.<br>2nd Bombay Brigade. | 1st N.I. (Grenadiers).<br>5th N.I.<br>23rd N.I. |

# APPENDIX III.

## FORMATION OF MAJOR-GENERAL POLLOCK'S COLUMNS AT THE FORCING OF THE KHAIBAR PASS, 1842.

### Left Column.

2 companies 9th Regt.
4 „ 26th N.I.
400 Jazailchis.
7 companies 53rd N.I.
3 „ 60th „
4½ „ 64th „
Torabaz Khān's men (Mohmands).
1¼ companies 9th Regt.

### Centre Column.

The Major-General.
Gren. Company 9th Regt.
1 company 26th N.I.
3 companies 30th „
2 „ 33rd „
Sappers and Miners.
Pioneers.
4 guns Horse Artillery.
2 „ Military Train.
3 „ Foot Artillery.
2 squads. 3rd Lt. Dragoons.
Camels.
1 company 53rd N.I.
Camels.
1 company 53rd N.I.
1 squadron 1st B.C.
Baggage and followers.
100 men Irregular Cavalry.
Baggage and followers.
1 squadron 1st B.C.
Dhoolis.
Camels, ammunition.
Major-General McCaskill.
3 guns Foot Artillery.
10th Light Cavalry.
1 squadron Irregular Cavalry.
2 squads. 3rd Lt. Dragoons.
2 guns Horse Artillery.
Camels, treasure, &c.
Dhoolis.
1 squadron 1st B.C.
Camels, stores.
3 companies 60th N.I.
1 company 6th N.I.
1 „ 9th Regt.

### Right Column.

2 companies 9th Regt.
4 „ 26th N.I.
400 Jazailchis.
7 companies 30th N.I.
3 „ 60th „
4 „ 64th „
Broadfoot's Sappers.
1½ companies 9th Regt.

# APPENDIX IV.

## MARCHES AND DISTANCES BETWEEN FĪROZPŪR AND KĀBUL.

| Miles | | 1838 | Marches |
|---|---|---|---|
| 454 | Fīrozpūr to Sakkar . . | 10th December to 24th January . | 38 |
| 171 | Sakkar to Dādar . . . | 16th February to 10th March . . | 25 |
| 86 | Dādar to Shālkot . . . | 16th March to 26th March . . . | 8 |
| 148 | Shālkot to Kandahār . | 7th April to 26th April. . . . | 14 |
| 230 | Kandahār to Ghaznī . . | 27th June to 21st July . . . . | 22 |
| 88 | Ghaznī to Kābul . . . | 30th July to 6th August . . . . | 7 |
| 1177 | | | 114 |

Fīrozpūr to Kābul, 239 days. Average distance per diem just under 5 miles.

# APPENDIX V.

## CHRONOLOGY OF THE CAMPAIGNS.

### 1837.

| | |
|---|---|
| 20 Sept. | Sir Alexander Burnes arrives at Kābul. |
| 23 Nov. | Herāt besieged by the Persians. |
| 19 Dec. | Arrival of Captain Vikovitch at Kābul. |

### 1838.

| | |
|---|---|
| 26 April | Burnes quits Kābul. |
| May | General Simowich arrives before Herāt. |
| 24 June | Failure of Persian attempt to storm Herāt. |
| 26 June | Signature of the Tripartite Treaty by Ranjīt-Singh. |
| 9 Sept. | Muhammad Shah raises the siege of Herāt. |
| 13 Sept. | Sir Henry Fane issues a General Order detailing the force for Afghānistān. |
| 1 Oct. | Issue of the Governor-General's Declaration (The Simla Manifesto). |
| 22 Oct. | News of raising of siege of Herāt received by Government of India. |
| 25 to 28 Nov. | The Bengal force assembles at Fīrezpūr. |
| 27 Nov. | Order for reduction of the force. |
| 29 Nov. | Interview between the Governor-General and Ranjīt Singh. |
| 27 Nov. | Landing of Sir John Keane at the mouth of the Indus. |
| 10 Dec. | Bengal force moves from Fīrozpūr. |
| 29 Dec. | Bengal force reaches Bhāwalpūr. |

### 1839.

| | |
|---|---|
| 1 Jan. | Bengal force marches from Bhāwalpūr. |
| 24 Jan. | Bengal force reaches Rohrī. |
| 30 Jan. to 15 Feb. | Sir Willoughby Cotton's march towards Haidarābād and return to Sakkar. |
| 19 Feb. | Sir Willoughby Cotton marches from Sakkar. |
| 16 March | Sir Willoughby Cotton enters the Bolān Pass. |
| 7 April | Sir John Keane marches from Shālkot. |
| 26 April | Sir John Keane reaches Kandahār. |
| 27 June | Sir John Keane leaves Kandahār. |
| 23 July | Capture of Ghaznī. |
| 7 August | Entry of Shūja-ul-Mulkh into Kābul. |
| 12 Sept. | A small force sent to Bamiān. |
| 18 Sept. | Major-General Willshire marches from Kābul with the Bombay Column. |
| 15 October | Sir John Keane leaves Kābul on return to India. |
| 13 Nov. | Capture of Kalāt by Major-General Willshire. |

1840.

| | |
|---|---|
| 18 Jan. | Repulse at Pashūt and its subsequent occupation. |
| April | Sir Wm. Macnaghten proposes to send a brigade to Bokhāra. |
| April | Ghilzai rising. Captain Anderson's action at Tazī. |
| 7 May | Lieut. Clarke's detachment destroyed in Sartaf Pass. |
| 12 May to 28 Sept. | Defence of Kahun by Captain Lewis Brown. |
| 21 June | Shālkot attacked by Balūchīs. |
| Middle of August | Kalāt taken by the insurgents. |
| 12 August | Defeat of Major Clibborne in the Nafusk Pass. |
| 18 Sept. | Brigadier Dennie defeats Dost Muhammad and the Wali of Khulm at Bamiān. |
| 29 Sept. | Brigadier Sale gains the action of Tūtan-dara. |
| 3 Oct. | Fort of Jalgāh unsuccessfully assaulted by Sale. |
| 28 Oct. | Attack on Dādar, by the Balūchis, repulsed. |
| 2 Nov. | Action of Parwan-dara. |
| 13 Nov. | Kalāt retaken by Major-General Nott. |
| 14 Dec. | Return of Nott to Kandahār. |

1841.

| | |
|---|---|
| 3 Jan. | Captain Farrington defeats Akhtar Khān, Dūrānī. |
| 12 Jan. | Brigadier Valiant's brigade moves from Karāchi. |
| Feb. | Colonel Wilson defeated and killed at Sībī. |
| | Colonel Shelton's operations in Naziān. |
| | Major Todd withdraws from Herāt. |
| | Rebuilding of Kalāt-i-Ghilzai. |
| 19 May | Lieut.-Colonel Wymer defeats the Ghilzais, at Īlmī. |
| 3 July | Captain Woodburn defeats Akhtar Khān on the Halmand, near Gir'shk. |
| July | Nassir Khān surrenders to Colonel Stacey. |
| 5 August | Colonel Chambers beats the Ghilzais near Ghaznī. |
| 17 August | Captain Griffin defeats Akram and Akhtar Khān at Sikandarābād. |
| Sept. | Reduction of the Ghilzai stipends. |
| | Akram Khān captured by General Nott. |
| | Execution of Akram Khān. |
| | Revolt of the Ghilzais. |
| 12 Oct. | Brigadier Sale clears the Khurd Kābul Pass. |
| 1 Nov. | Insurrection in the Kohistān. |
| 2 Nov. | Murder of Sir A. Burnes. |
| 13 Nov. | Sale occupies Jalālābād. |
| 16 Nov. | Monteath defeats the enemy before Jalālābād. |
| 17 Nov. | Maclaren's brigade marches for Kābul. |
| 1 Dec. | Dennie routs the enemy before Jalālābād. |
| 8 Dec. | Maclaren's brigade re-enters Kandahār. |
| 23 Dec. | Murder of Sir Wm. Macnaghten. |

1842.

| | |
|---|---|
| 6-13 Jan. | Destruction of Kābul brigade. |
| 12 Jan. | Nott's sortie from Kandahār. |
| 19 Jan. | Colonel Wild's failure in the Khaibar Pass. |
| | General Pollock arrives at Kawalsar. |
| 7-9 Mar. | Nott's operations on Tarnak and Argand āb. |

1842—(*continued*).

| | |
|---|---|
| 10 March | Attack on Kandahār. |
| 18 March | Surrender of Ghaznī by Colonel Palmer. |
| 25 March | Colonel Wymer defeats the Dūrānis at Bāba Wali. |
| 28 March | Defeat of General England at Haikalzai. |
| 5 April | Forcing of the Khaibar by General Pollock. |
| | Murder of Shah Shūja. |
| 7 April | Sale's sortie from Jalālābād. |
| 16 April | Relief of Jalālābād. |
| 21 April | Assault on Kalāt repulsed. |
| 28 April | Major-General England's second action at Haikalzai. |
| 10 May | Wymer and England reach Kandahār. |
| 20 May | Assault on Kalāt-i-Ghilzai repulsed by Captain Craigie. |
| 26 May | Relief of Kalāt-i-Ghilzai by Colonel Wymer. |
| 29 May | General Nott defeats Akhtar Khān, of Zamīn Dāwar, at Bāba Wali. |
| 26 July | Monteath chastises the Shinwāris. |
| 8 August | Nott marches from Kandahār. |
| 20 August | Pollock marches from Jalālābād. |
| 28 August | Nott: Affairs of Mūkūr and Ghoain. |
| 6 Sept. | Recapture of Ghaznī by General Nott. |
| 7 Sept. | General Pollock leaves Gandamak. |
| 8 Sept. | General Pollock's action at Jagdalak. |
| 13 Sept. | General Pollock's action at Tezīn. |
| 14 Sept. | General Pollock's action at Haft Kotal. |
| 15 Sept. | General Pollock encamps at Kābul. |
| 17 Sept. | General Nott encamps at Kābul. |
| 29 Sept. | Istālif taken by Major-General McCaskill. |
| 12 Oct. | Generals Pollock and Nott leave Kābul. |
| 19 Dec. | General Pollock crosses the Satlaj at Fīrozpūr. |
| 23 Dec. | General Nott crosses the Satlaj at Fīrozpūr. |

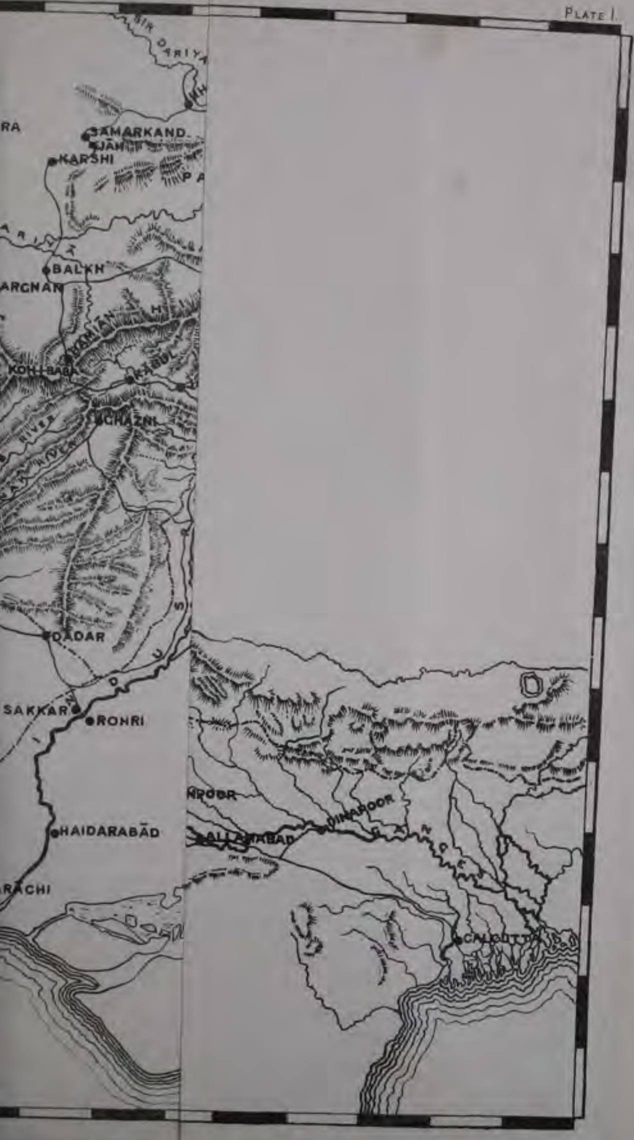
SIR DARIYA
SAMARKAND.
KARSHI
BALKH
BAMIAN
KOH-I-BABA
KABUL
GHAZNI
RIVER
DADAR
SAKKAR
ROHRI
HAIDARABĀD
RACHI
ALLAHABAD
DINAPOOR
CALCUTTA

TABLE I.

| Experiments. | Material of Target. | Nature of Ordnance. | Chrge | Nature of Shell. | Weight of Shell. | Range. | Penetration. | Further Results. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | | | lbs. | | lbs. | yards. | | | |
| *a* | Brickwork; ("good mortar, soft bricks.") | 64 pr. R.M.L. | 12 | Palliser Chilled. | 90 | 1040 | 8ft. | After piercing this wall, shell proceeded onwards "with considerable velocity." | Part of a Martello Tower; masonry of "fairly good quality." |
| *b* | Portland cement concrete; ("fair quality," 1 pt. cement 3 pts. sand, 5 pts. shingle.) | do. | 10 | do. | do. | 1103 | 4ft 8ins. | Shell loaded, but not fused, and did not explode. | Against an epaulment prepared for purpose. |
| *c* | Ditto. | do. | do. | Common | 64 | do. | 2ft 6ins. | Shell as above, burst on impact. | Against same epaulment. |
| *d* | Ditto (not so good quality; 1 pt. cement, 4 pts. sand, 6 pts. small shingle.) | do. | 12 | do. | do. | 1070 | 4ft. | Shell burst after full penetration & broke up concrete to width of 10ft. | Against another epaulment. |

*Extract from Remarks of Committee.*

"Concrete shows a decided superiority over brickwork in its power of resisting the penetration of projectiles. . . . . It is very necessary to chose a material for concrete which shall give a good surface for the adhesion of the cement, shingle not being suitable in this respect. . . . . . . The proportion of cement should not be less than 1 in 8. . . . . . . In order to penetrate good concrete a projectile much stronger than the service 64-pr. common shell is required."

Plate IV.

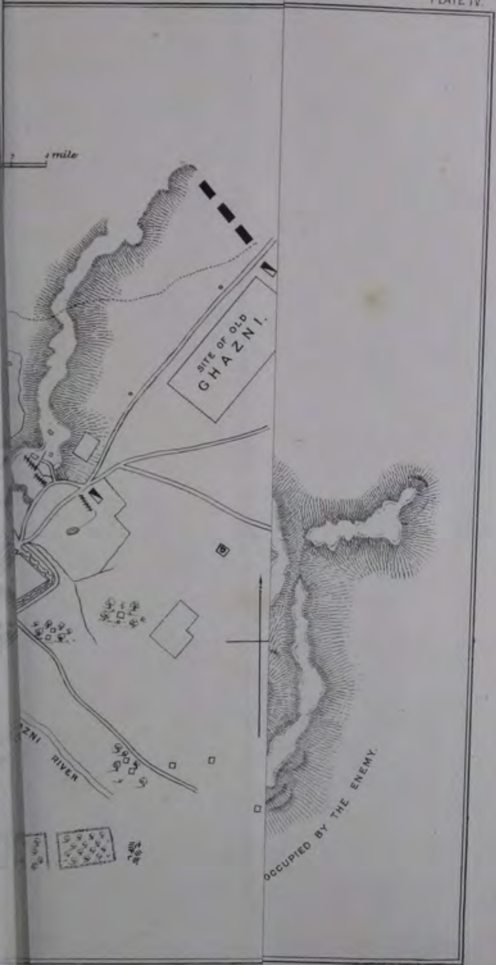

TABLE II.

Experiments in Table I. corrected to give approximate Penetrations with an uniform charge, weight of Shell, and Range, of 10 lbs., 90 lbs., and 100 yards respectively.

| Experiments. | Material of Target. | Penetration. | Remarks. |
|---|---|---|---|
| *a.* | Fair Brickwork. | 10 feet. | Allowance has been made for residual velocity of shell after piercing wall. |
| *b* & *c.* | Fair Portland Cement Concrete. | 4 ft. 8 ins. | |
| *d.* | Poor Portland Cement Concrete. | 7 ft. 6 ins. | |

## PAPER VIII.

### HISTORICAL SKETCH

OF THE

# DEFENCES OF MALTA.

BY

WALTER H. TREGELLAS,
*Chief Draughtsman, War Office.*

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THE defences of Malta were so insignificant when the islands came into the possession of the Knights of St. John of Jerusalem, in 1530, and the subsequent history of the fortifications is so closely identified with that of the Order, that it will be sufficient to take only a very rapid glance at the history of Malta before the arrival of the Knights.

As is well known, Malta is mentioned by many of the writers of antiquity; and relics of most of the nations who settled there still bear testimony to the general accuracy of the accounts of the ancient classical writers.

First peopled, as it is said, by the Phœacians, then by the Phœnicians, Malta passed successively through the hands of the Greeks (736 B.C.), and the Carthaginians (528 B.C.), until it was finally attached to Rome during the second Punic war (218-202 B.C.). Under the Roman sway Malta attained a high pitch of civilization; and during this period was celebrated for its manufactures of cotton and linen, and for the magnificence of its public buildings, especially of its temples. After the fall of the Roman empire (though the Roman dominion was once more established for a short time under Justinian), Malta, like Sicily, was seized by the Vandals (about 454 A.D.), and by the Arabs in the ninth century. From the last-named people it again passed under the dominion of Greece for a short period; but the Arabs recovered their possession, and established a government dependent upon the Emir of Sicily. In 1090 A.D., the Arabs were driven out of the Island by Count Roger, the Norman, who established a principality in Sicily and Malta. The Maltese Islands now appear to have followed pretty nearly the fortunes of Sicily, passing under the German sway for a period of 72 years; till, finally, both Malta and Sicily fell under the sway of Spain after the tragedy of the Sicilian Vespers in 1282.

In 1530, after the fall of Rhodes, Charles V., into whose hands the whole of the Spanish Empire passed in 1516, at the instance of Pope Clement VII., granted Malta to the Order of St. John of Jerusalem, who retained it till the close of the last century.

The Knights found Malta an almost desolate rock, its decadence from the date of the first Roman occupation having been uninterrupted. Its only natural advantages were its harbours; and its only fortifications were those at Citta Nobile, in the centre of the Island; Fort St. Angelo, in the harbour of Valetta; and a weak ençeinte round the remainder of the Bourg peninsula—all of them weak and ill-armed. The population, however, was even then considerable, reaching it is said to 17,000.*

In July, 1551, the Turks, desirous of revenging themselves upon the Knights for having assisted certain of the Sultan's enemies, made a descent upon Malta. They landed at Marsa Musceit, but they so highly estimated the strength of Fort St. Angelo and the Bourg, then the only defences of Valetta (see *Plate* I.), that they determined not to attack it, and moved on to Citta Nobile. Here also, the fortifications foiled them; and they retired, after ravaging the Island of Goza.

A more formidable attack was made by the Turks on the 18th of May, 1565; by which time St. Elmo, the fortifications of Sanglea, and those of the Bourg, had been added to the defences of the harbour.

The forces of the besieged consisted of the Maltese Militia, numbering 3,000 men, 500 pledged galley-slaves, and a large number of hired Spanish and Italian troops. Their total force was about 9,000 men, of whom 474 were Knights, and 67 servants-at arms; this number was, however, subsequently augmented by 100 Knights. The Turks held the command of the sea with 150 galleys,

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* Blondel says that Malta contained 80,000 inhabitants in A.D. 1681. In A.D. 1800, there were 90,000, and at the present date there are probably about 105,000.

50 smaller vessels, and numerous transports. They had a force of 30,000 men, of whom 5,000 were janissaries. Their armament was in proportion, comprising 80-pounders and 60-pounders, and "one huge basilisk" throwing a 160lb. ball.* They disembarked partly at Marsa Sirocco, and partly at St. Thomas' Bay, perhaps, also, at some of the smaller harbours; but the chief rendezvous of the Turkish fleet appears to have subsequently been at Marsa Musceit.

The result of the siege is well known. After a series of vigorous attacks, which extended over a period of nearly four months, and which were repulsed with the utmost valour by the besieged, the Turks were compelled to withdraw on the 8th of September, 1565; they had battered St. Elmo into ruins, but the banner of the white cross still waved over the fortress of St. Angelo.

In 1615 the Turks made another descent upon the island; but, in the meantime, the defences had been considerably increased. St. Elmo had been rebuilt, the fortifications of St. Angelo, the Bourg, and Senglea had been strengthened, and Valetta had been enclosed with a strong enceinte. The result of this attack was, as might have been expected, futile.

During the seventeenth century, the Floriana front, the Fortress of St. Margaret on the Burmola Heights, the Cottonera Lines, and Fort Ricasoli were undertaken, and sundry minor improvements were effected.

In 1714-5, war was declared by the Turks against the Venetians. This led to a careful examination of the fortifications, and many improvements were made, whilst others (including Fort Manoel which was built shortly afterwards) were suggested. These were effected principally under the superintendence of the French engineers De Tigné and De Mondion, under the approval of Vauban. It was at this period also, that the occupation of the Corradino Heights was again recommended, as it had previously been by Blondel and Vernada, who had further pointed out the necessity of fortifying the high ground at Saint Salvador, between Fort Ricasoli and the left wing of the Cottonera Lines. Fort Tigné, constructed at the close of the eighteenth century, was the last work of defence built by the Order of St. John.

The character of the Order, which, during the sixteenth and earlier part of the seventeenth centuries, stood almost unparalleled for valour and morality, gradually deteriorated in the absence of occasions of war; and, on the 12th of June, 1798, the last Grand

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* Prescott states that two of the sixteen guns in the Turkish Battery on St. Salvador threw stone balls of 300lb. weight.

Master Hompesch surrendered the fortress of Valetta to Napoleon, with scarcely an attempt at its defence. This circumstance has been justly attributed, no less to the cowardice, incapacity, and blindness of the Grand Master, than to the notorious disaffection and treachery of those who served under him.

Malta was afterwards blockaded by Lord Nelson,* and, at the end of two years, was delivered up to General Pigot, on the 7th of Sept., 1800. It was ultimately assigned to England by the treaty of Paris, 30th of May, 1814.

Some further information as to the history of the works, down to the date of the surrender of Malta to Great Britain, will be found in the following pages. They are described, as far as their dates could be ascertained, in chronological order; but it should be observed that, owing to the conflicting accounts of different historians, the careless statements of some writers, and the changes which have been made in the names of places, only an approximation to accuracy must be expected. The writer also labours under the great disadvantage of never having visited Malta.

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*St. Angelo.*—When the Knights took possession of Malta in 1530, the Fort of St. Angelo, built according to tradition on the site of an Arab fortress, was the only protection of the principal harbour of Malta (see *Plate* I).

Though the fort had been considerably augmented during the reign of Charles V., it is described as being feeble and ill armed. It was repaired and strengthened by the Grand Master de L'Isle Adam,† who deepened the ditch, and made some further additions on account of rumours of a descent by the Turks in 1533. The Grand Prior of Toulouse, three years afterwards,‡ improved the bastions which flanked the castle, so as to enable them to thoroughly command the whole of the ditch from one harbour to the other.

In 1541, under the Grand Master d'Omedes, the ditches were again deepened, and a cavalier "according to the draught of Faramolin, the Emperor's engineer," was added to St. Angelo, which was intended to "dominate over Marsa Musceit."! Even as early as 1551, St. Angelo was so formidable as to cause the Turks to abstain

* A plan showing the sites of the blockading batteries is in the War Office, marked X32/8; of this plan G 56 is a copy.

† L'Isle Adam's palace is now the Field Officers' quarters; on the walls, under a coat of arms, is inscribed the date 1531, and in a grotto opposite the date 1533 occurs.

‡ The dates inscribed on the face of D'Omedes' bastion are 1536 and 1537, the date of its construction; and 1769 the date of its restoration.

from attacking it, on the occasion of one of their warlike expeditions to Malta.

La Valette made St. Angelo his citadel on the occasion of the siege of 1565; when, in addition to the Castle itself, which rose to a considerable height, two tiers of batteries defended the approach to the harbour.

There was also an "à fleur d'eau" battery for five guns constructed expressly to protect the spur of St. Michael-on-Sanglea. This appears to have been subsequently removed: its site would seem to have been the enclosure which now covers the sally-port. This little work probably saved the fortress; as its guns, loaded with grape, and fragments of iron, sank nine out of the ten boats with 1,000 janizaries on board, which were sent as a re-inforcement after the failure of the first attack on Fort St. Michael.

According to one authority, the platform below St. Angelo was the work of the Grand Master Nicholas Cottoner; and the same writer states, that the four batteries defending the entrance of the harbour were constructed about 1715, during the Grand Mastership of Raymond Peirelos, by Don Carlos de Grunemburg, the King of Spain's engineer.

The date 1690 is inscribed over the main gate in the south wall of the ençeinte.

*Vittoriosa.*—Even before the siege of 1565, there was some sort of defence round the peninsula on which the town of the Bourg (Vittoriosa) was situated. Here the Knights settled, and fixed their convent; strengthening such work as existed, and completing the ençeinte (see *Plate* I.). Vertot states, that, at this period, the Bourg was encompassed by a ditch of small depth, and ill-flanked; and that, by way of protection against pirates, two bastions were subsequently added. These appear to have been the Bastions of St. John and St. James.

At the date of the siege of 1565, the land front had a line of ramparts broken into two complete bastions in the centre, and having a demi-bastion at either wing. There was a deep ditch, and, according to some authorities, also outworks. (See *Fig.* 1, *Plate* IV.) The sea-face of the ençeinte was bastioned; on the Sanglea side it is doubtful whether there was even a curtain; but the entrance to the Port of Galleys was closed by a huge chain drawn across it from Fort St. Angelo to the Point of Sanglea.

The conspicuous part played on this occasion by this portion of the fortifications, and especially the gallant defence of the Post of

Castille are well known, and the name of Vittoriosa was conferred upon the Bourg by the Grand Master de la Valette.

No additions of great importance appear to have been made during the next 150 years; but, amongst the reforms carried out in pursuance of the project of 1716, may be noticed a covert way in front of the curtain, and also a new bastion at the Post of Castille, probably that now known as the Castille horn-work.

The dates 1722 and 1723 are inscribed on the escarp over the Advanced Gate and Vittoriosa Gate respectively.

*Senglea.*—According to Vertot and other writers, some part of the fortifications was commenced in the time of the Grand Master d'Omedes, in 1541; but it does not appear that the complete occupation of this peninsula was undertaken until 11 years afterwards, towards the close of d'Omedes' Grand Mastership, on the recommendation of Strozzi, in 1552. The object in view was the same as that for which St. Elmo was built, viz., the protection of St. Angelo; and it is stated that both Fort St. Elmo and Fort St. Michael* were ready to receive their armaments in 1553.

The honour of constructing Fort St. Michael is sometimes, though probably erroneously, assigned to the Grand Master de la Sangle, who succeeded d'Omedes, in 1553. De la Sangle doubtless strengthened the works considerably, and it was he "who enclosed Mount St. Michael (the whole promontory) with a bastioned trace." The new town was called after this Grand Master; the Bourg now receiving the name of the Old town. We find Senglea described as being, at the date of the Turkish siege, in 1565, "protected by a very respectable sea front, at its extremity broken into four bastions." The seaward ramparts were probably strengthened just before the arrival of the Turks. (See *Fig.* 2, *Plate* IV.)

Senglea was the first point of their attack after the fall of Fort St. Elmo, and the Spur Bastion was selected as the point to be breached. It is noteworthy that the Turkish galleys approached this part of the works, not up the Grand Harbour, which was efficiently guarded by Fort St. Angelo, but by dragging their boats across the isthmus at the head of the Marsa Musceit.

The project of 1716 provided for the following services, viz.:—

The right bastion, exposed to Corradino, to be altered.

The ditch in front of the entrance to be opened. A covert way to be constructed along the front. A retrenchment to be made.

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* This term, perhaps, applies not only to Fort St. Michael itself, but also to the whole promontory, which is called in a map in the War Office, (Z 31/51), "L'Isle de St. Michel de Sangle."

But it does not appear that these services were executed.

The only date inscribed on the walls of the Senglea fortifications appears to be that over the entrance to the tower at Isola Point Battery, it is 1692.

*St. Elmo.*—The occupation of this position was undertaken on the recommendation of Strozzi, about 1552, chiefly in order to cover Fort St. Angelo; and owing to the vigorous exertions which were made to complete the work, the Castle was ready to receive its armament in May, 1553. It is said to have been called St. Elmo by the Knights, in commemoration of one of the towers that guarded the entrance to Rhodes.

Additions were made to it by the Grand Master de la Sangle between 1553 and 1557; and we find that St. Elmo is described as being, at the date of the Turkish siege in 1565, "a star fort of four angles, to the seaward of which was a cavalier dominating over the work, and covering the left angle of the enclosure was a ravelin." This ravelin appears to have stood just where the Artillery store, St. Lazarus Bastion, now is.

The garrison for this post must have been very small owing to the contracted dimensions of the work.

This was the first point of attack from the land selected by the Turks; and to their vastly superior forces St. Elmo fell, on the 23rd of June, 1565, after a vigorous siege of upwards of a month, and after having made a most valiant defence, the honours of which are scarcely diminished by the fact that the losses of the day were, until the latter part of the siege, renewed during the night by succours from Fort St. Angelo across the harbour.

The Turks razed St. Elmo to the ground, and sent 30 cannon from the fort to Constantinople as trophies; but de la Valette, on their withdrawal from Malta, determined to reconstruct it, on the same model, but on a larger scale.

It is stated in Porter's *History of the Knights of Malta*, that St. Elmo was almost entirely rebuilt, as it stood in 1717, during the Grand Mastership of Gregory Caraffa, who was elected in 1680, and died 1690; but in Giacomo Lauro's* *Pianta e breve Historia dell 'Isola di Malta, Roma, 1636*, St. Elmo, in 1635, is represented as shown in *Fig.* 3, *Plate* IV.; and it is stated by another authority, that "the tower of St. Elmo" was built "as it now stands" (1800) in 1637.†

* British Museum. $\frac{\text{C. 46 } d.}{1}$

† An inscription on the chapel altar is dated 1649. $\left(\frac{\text{Malta 5}}{1146}\right)$

It is, however, certain, from Blondel's description of the fortifications of Malta, in 1681, that, at that period, the ditches and *counterscarps* on the seaside were only *commenced*; so that the sole way of reconciling these discrepancies would be to suppose that Lauro's plan represents St. Elmo as reconstructed after the siege of 1565, on pretty nearly the old foundations; and that the work of Caraffa was confined to removing the land front cavalier, and filling in the ditch which separated the seaward cavalier from the main work.

The tanks and part of St. Gregory's Bastion occupy an old ditch or cut, which stretched from the re-entering angle on the western side of the fort down to Marsa Musceit; and a similar cut on the eastern side, in prolongation of the ditch which originally separated the seaward cavalier from the fort, appears to have been filled in when Abercrombie's curtain was made. Indications of both of these ditches are still to be noticed along the coast line.

*Valetta.*—It was the original intention of the Knights, on their arrival at Malta, in 1530, to have taken up their residence on the Valetta peninsula—then known by the name of Mount Sceberras;* but the costliness of this undertaking, and the impaired resources of the Knights after the fall of Rhodes prevented its accomplishment at that time. The project was revived by Strozzi, in 1552, and was again urged by the Grand Master de la Valette, in 1557; but it was not until after the Turkish siege of 1565, that, in consequence of contributions received from some of the leading courts of Europe, whose monarchs were struck with admiration at the valiant deeds done by the Knights on behalf of Christendom, that de la Valette found the means for commencing the fine city which bears his name.

The foundation stone of the new fortifications was laid at the corner of St. John's Bastion, on 28th March, 1566,† and they were completed in March or May, 1571.‡ It is stated that the original design of de la Valette was to cut down Mount Sceberras to a level platform, but the rumour of a fresh attack by the Turks put a stop to this laborious operation.

The new works were intrusted to Francesco Laparelli (an engineer sent by the Pope for that purpose), and to Jerome Cassan, the engineer of the Order of St. John; but it is believed that the trace of the works was designed by de la Valette himself.

*Plate* III., traced from a contemporary engraving in the

* Scêberras signifies in Arabic a place elevated above another.
† 1567 is inscribed on one of the angles of St. John's Cavalier.
‡ The date 1568 is inscribed on the German curtain, and on the Marsa Muscetto sallyport. The Marsa Muscetto Barracks are dated 1550, and the Porta Reale, 1634. $\left(\frac{\text{Malta 5}}{1446}\right)$.

British Museum, is nearly identical in its main features with the present plan of the works; but St. Andrew's Bastion was made much stronger than shown in the original design, and the Lascaris counterguard was added subsequently, probably about 1640.* The chief difference, however, consists in the absence of the counterguards on the land front, which were added by the Marquis de St. Ange about 1640. These portions of the work, formerly known as the Marquis of St. Ange's counterguards, are said to have been constructed in consequence of a report dated 1638, by an Augustine Monk, Fiorenzuola,† who condemned the Floriana works as useless. St. Magdalen Ravelin, in front of Porta Reale, was also the work of St. Ange.

Blondel states that, in consequence of St. Ange not having been provided with sections of the ground, the height of the counterscarp was unnecessarily reduced by two toises (12′ 9½″).

The reforms of 1715 consisted chiefly in repairing the parapets, completing the communications, making caponiers and traverses in the ditches, adding traverses to the covered way, and making bomb-proof the magazines at Porta Reale.

*Floriana.*—The occupation of this ground, as well as of Valetta, was recommended by Strozzi, in 1552, but it was not until 1636, on the rumour of another Turkish attack, that the Grand Master Lascaris engaged an eminent Italian engineer (Col. P. Florian) to construct an advanced front, which should afford additional protection to what was then considered almost the only weak point in the fortress.

The work was severely commented on at the time as unnecessary, and ill-placed. The Marquis de St. Ange, for instance, recommended, in 1640, that the works, which were then only partially completed, should be brought much nearer to the Valetta land front; and again, in 1671, the Count Vernada, chief engineer to the Venetian Republic, condemned this part of the fortifications as being on too small a scale.

The horn-work and crown-work appear to have formed a subsequent addition,‡ and it is believed were designed by Count Valperga the engineer of the Cottonera lines.

* On a tablet in the escarp over the communication at Lascaris counterguard is a long Latin inscription commemorating the completion of a system of water supply to Valetta by the Grand Master Lascaris—the date on this tablet is 1642.

† It was Fiorenzuola who designed the fortification of St. Margaret, Burmola.

‡ A plan in the War Office, marked Z 31/51, shows the Floriana front without the horn-work and crown-work.

Some minor improvements were made in the works, at the suggestions of the engineers Blondel and Grunemburg; but the Floriana fortifications were not brought into their present finished state until after the completion of sundry additions recommended in the project of 1715.

Valperga, Blondel* and De Tigné† all recommended the occupation, to a certain extent, of the Floriana place d'armes, by buildings, with a view to preventing the over-crowding of Valetta; as well as in order to provide the necessary lodgings for the defenders in time of siege. It is scarcely necessary to observe that these recommendations have hitherto been only partly carried out.

The only date on this part of the fortifications appears to be that of 1721, on the Porte des Bombes.

*Burmola.*—The first design for the fortifications of St. Margaret (so called from a chapel which was in the ditch) was given to the Grand Master Lascaris, between 1638-42, by a monk named Fiorenzuola; the object being to cover the Port of Galleys from the fire of an enemy's batteries, which might otherwise have been constructed on these heights, as was done by the Turks in the siege of 1565.

The original design, as appears from several old plans,‡ was for a "castle"‖ only, and included magnificent gardens and pleasure grounds; but the work seems never to have never been finished until after De Tigné, in 1715, desirous of providing some sort of shelter for the country people in anticipation of a then rumoured attack, recommended the completion of the Burmola lines rather than incurring the enormous expenditure necessary to put the Cottonera lines into a thoroughly efficient state.

The right and left sections of the lines appear to have been built accordingly at his suggestion; and the three bastions now known as St. Elena,§ Fiorenzuola, and St. Margarita were constructed upon the already existing foundations of the old Castle of St. Margaret.

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* $\frac{\text{Reports}}{120}$.

† $\frac{\text{Reports}}{121}$, pp. 36 and 37.

‡ One of which is Z 31/50 in the War Office.

‖ It is noteworthy, that the entrenched work Fort Verdala, built on the recommendations contained in Colonel Harding's Report of 1844 $\left(\frac{\text{Reports}}{66}\right)$ occupies just the site of the foundations of the original Castle. The St. Clement's retrenchment was also built in accordance with Colonel Harding's project.

§ The date 1736 occurs over the entrance of St. Elena gateway.

*Cottonera.*—The Cottonera lines—still unfinished— are due to the ambitious design of the Grand Master Nicholas Cottoner; the object which he had in view being, not merely the occupation of the ground, and consequently the denial of it to an enemy, but also the enclosure of a large defended area within which the country people might find security for themselves and their property in the event of further attacks upon the island. This object would, indeed, have been partially attained by the completion of the Burmola lines, after the manner subsequently recommended by de Tigné in 1715; but the space so enclosed would doubtless have been insufficient for the purpose, and certainly was not in accordance with the ambitious character of the above-named Grand Master.

The scheme was from the first considered too magnificent, not only by the Order of St. John, but also by the French Emperor, to whom the plan was submitted; and it was severely criticised by General Beretta, Engineer of the States of Milan, on the 4th of December, 1670, on account of the regularity of the trace being unsuited to the nature of the ground, &c. The Count Verneda, Chief Engineer of the Republic of Venice, gave a somewhat similar report on the works, dated 30th of July, 1671, and showed how, with the same length of line, a much larger space might have been included. Similar opinions have been expressed by almost every engineer who has since reported upon the Cottonera lines.

The first stone had, however been laid at St. Nicholas bastion, on the 28th of August, 1670;* and an Italian Engineer, the Count de Valperga, in the service of the Duke of Savoy, was appointed to carry out this stupendous project.

For ten years the works were prosecuted with energy, but they then languished for want of funds. Their condition in 1681, may be readily gathered from that part of the Chevalier Blondel's report which refers to them.†

This celebrated engineer appears to have had the superintendence of the works, under Valperga; and both his opinion and that of de Tigné agreed with those which had been previously expressed by Beretta and Vernada.

After a lapse of 35 years from the cessation of the works in 1680, —the lines having up to that time been raised to the height of the cordon throughout, and the parapets having been constructed in some parts—in 1716 parapets were added to the bastions of St. Peter, (St. Nicholas ?), St. Paul, St. John, and St. Clement, and to their intermediate curtains.

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* The date 1675 is inscribed on a marble tablet over the Zabbar Gate.
† See *Appendix* II.

It is believed that counterscarps were also constructed about this time where the ground was low; and that such ditches as existed were deepened at some places, and their bottoms levelled. De Tigné's object in proposing these reforms seems to have been merely to put the lines into such a state of defence as would enable them to resist a *coup-de-main*. It was at his suggestion that the retrenchment in St. Salvador bastion was constructed.* But, as has been before stated, it was the opinion of this engineer, that, under the exigences of the case which then existed, the completion of the Burmola Lines was of the first importance.

The construction of the St. Clement's retrenchment, in pursuance of the recommendation contained in Colonel Harding's Report of 1840,† has already been adverted to.

*Fort Ricasoli.*—On the point of land on which Fort Ricasoli now stands was placed one of the batteries raised by the Turks during the memorable siege of 1565. During the earlier portion of the attack it appears that this position was not occupied by the Turks; but the necessity, which soon became apparent, of preventing the occupants of St. Angelo from throwing succours into the beleaguered fortress of St. Elmo during the night, finally led to a battery being placed here. Other batteries appear to have been erected here at a subsequent period of the siege, the fire of which was directed against the sea front of the Bourg.

A small tower, constructed for the protection of the mouth of the harbour, and called, according to different writers, by the various names of Corso, Orsa, and Santa Petronia, stood at the extremity of the point at the latter part of the seventeenth century. It was described by Blondel as being old then, and he counselled its removal; but nothing farther is known as to the date of its construction than that it is said to have been erected at the expense of one of the Knight Commanders, called Petronia.

In 1640, the Marquis de St. Ange designed a work for this point; but his project was not carried out. It was reserved for Valperga, the engineer of the Cottonera Lines, to build Fort Ricasoli, which was commenced about 1670, and was called after a Knight Commander of that name who made a donation towards it of 30,000 crowns.

The work was severely criticised by Blondel (who appears to

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* The date 1724 is inscribed on a marble tablet over the entrance gateway of Fort Salvatore.

† $\frac{\text{Reports}}{66}$.

have carried out Valperga's design), chiefly on account of the smallness of its members; and in 1681 he suggested several alterations and additions, amongst which may be mentioned a ravelin at the point, with a powerful sea battery *à fleur d'eau*. The date 1698 occurs over the main gate.

The traverses and place d'armes appear to have been added to the covert way, in pursuance of the projects of 1716; to this period, also, may probably be referred the demi-guard on the left side, the two caponniers, and sundry minor improvements.

*Fort Manöel.*—There are different reports as to the origin of this work. According to one account its construction was occasioned by a futile attempt made by the Turks to obtain the release of some Mussulman slaves; but it seems more probable that its occupation was determined upon rather with a view to denying to an enemy a position from which some portions of the Valetta and Floriana works might be taken in reverse.*

A lazaretto was commenced here during the reign of Nicholas Cottoner, 1663–80; and, in 1681, we find Blondel writing of a proposed fort here, as designed by Valperga. It is also said that a project for its construction was drawn up in 1686, under the Grand Mastership of Gregory Caraffa.

The design, however, from which Fort Manöel was ultimately built was made, according to Vertot, by De Tigné, in June, 1723, on his third voyage to Malta; and the execution of it was carried out under the Chevalier de Mondion. The estimated cost of the work was 25,000 crowns (2s. each), and the fort was called after Antony Manuel de Vilhena, during whose Grand Mastership the work was constructed.

The date 1726 is inscribed over the main gate, and on a marble slab inside the chapel the date 1755 occurs.

*Fort Tigné.*—On point Dragut (so called after the Turkish corsair who established a battery here during the Turkish siege of 1565) this fort was built about 1793,† during the rule of the Grand Master Emmanuel de Rohan

In 1681, however, Blondel writes of a proposed fort here; the design, like that for Fort Manöel, having probably been given by the

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* See De Tigné's Report of 1715, $\frac{\text{Reports,}}{121}$ p. 98.

† On the escarp of the right face of the work the date 1792 occurs; and over the gateway is the following inscription "Anno Principatus Decimo Septimo ædificavit" (Emmanuel de Rohan)—these two dates are, therefore, coincident.

Count de Valperga. It was also included in the project of 1716, at an estimated cost of 3,000 crowns. But, as before stated, it was not built until a much later date, and was so called after the Grand Prior of Champagne, named De Tigné, who contributed largely towards the expenses of its construction.

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*Citta Nobile or Vecchia.*—When the Knights of St John arrived at Malta, in 1530, Citta Nobile was defended by weak and insignificant ramparts, ill-armed. It is not known by whom, or at what precise date they were erected; but there is a tradition that they occupied the site of still more ancient works, which were destroyed in 1455 by order of King Alphonso.

Citta Vecchia possesses considerable interest; not only on account of its being the seat of the Bishopric, and as containing some remarkable buildings, including the Palazzio Magistrale (built it is said on the site of an ancient fortress), but also on account of the valuable part which it played, as a citadel, during the siege of 1565. On this occasion a reserve force of the Knights issuing thence was the immediate cause of the raising of the siege; the Turks believing the small army which attacked their rear to be the vanguard of those succours whose arrival was daily expected from Sicily.

The important part played on this occasion by Citta Vecchia has caused most writers on the defence of Malta, down to the close of the last century, to attach some importance to the necessity of maintaining this post.

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*Coast Defences.*—Though the origin of these defences is somewhat obscure, their construction was doubtless first prompted by the successful landing of the Turks at Marsa Sirocco in 1565; but there is little or no evidence to prove that any of them were constructed at an earlier date than 1610, during the Grand Mastership of Alof de Vignacourt (1601–22); and of many of them it seems now impossible to give the history.

*Amongst the earliest appear to have been St. Lucian's Tower, in Marsa Sirocco; St. Paul's Tower, in St. Paul's Bay; the two redoubts at the Port of Ben Warrat; Hallis Tower, eastward of the latter; and St. George's Tower, in St. George's Bay: all of which were probably constructed about 1610. St. Thomas's Tower, at Marsa Scala, built in 1615, appears to come next in the order of

* The chief part of the following information as to the history of the coast defences is derived from a report drawn up by Lieut. J. Davies, R.E., dated 31st of January, 1868 $\left(\frac{\text{Malta 5}}{1871}\right)$.

date; and then followed the Tower of Della Garcia, on the coast, a short distance east of Fort Ricasoli; the Towers of Lissia and Ayn Toffiha on the western coast; Ransa Tower, in St. Paul's Bay; and the Madalena Tower between Cala St. Marco and St. George's Bay; all of which were constructed about 1620. All of the foregoing were built by the Grand Master Vignacourt.

The next Grand Master who appears to have turned his attention to the defences of the coast line was Martin de Redin (1657–60) Early during his tenure of office the following works appear to have been constructed:—the Vendome Tower and St. George's Redoubt at Marsa Sirocco; one of the towers on the south coast known as the Hamma Tower; Ghoshien Tower on the western coast; Ayn el Rasul Redoubt at Melleha Bay; and the Tower of L'Ahmar (a *point d'appui* for the line of redoubts on the western coast); Mistra Redoubt at St. Paul's Bay; and Hallis Redoubt and the Tower of Cala St. Marco at the Bay of the latter name.

The succeeding five Grand Masters do not appear to have done anything to the coast defences. But, under Raymond Peirelos, the following additions were made in 1715, towards the close of his reign, namely: Zoncar Tower, and Nyed el Ayn Redoubt, at Marsa Scala; Delliha Redoubt at St. Paul's Bay; and the Redoubt at the head of Cala St Marco.

The Grand Master Zondodari made only the two following additions, in 1721, viz.:—the Tower and Redoubt at Marsa Sirocco, which bear his name.

Emmanuel Pinto (1741-73) appears to have been the last of the Grand Masters who made any additions to this part of the defences of Malta. With the single exception of Budjabbu Redoubt in St. Paul's Bay, built in 1770, all the works of this Grand Master are said to have been built in 1761. They consist of the following, viz.: Manöel Redoubt, in St. Thomas's Bay; Sciorpilagoi Tower, between it and Marsa Sirocco; Ferretti, Pinto, Elminiech, and Balbini Redoubts, and the Towers of Cala Frana and Benghysa in Marsa Sirocco; Ghemuna Redoubt, in St. George's Bay; and St. Julian's Tower, in the Bay of that name.

Of the foregoing only two are now occupied by the Imperial Government, namely, the Towers of St. Julian and St. Lucian. About twenty of them were abandoned in 1832, and the remaining sixteen were handed over to the Local Government, in 1853.

There is a full description of the coast defences, drawn up at the close of the last century, in the third paper of $\frac{\text{Reports,}}{122}$ and also, in $\frac{\text{Reports}}{125}$, by Capt. Dickens, R.E., 10th of October, 1813; both of which contain proposals for strengthening and increasing the works.

There is, besides, a detailed list of them, with their armaments, consisting altogether of 250 pieces of artillery, besides *fougaces*, given in *Appendix*, No. IV., of Bois-gellin's *Ancient and Modern Malta*, 1804.

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*Goza and Commino.—Goza.*—The ancient castle of Goza, situated in the centre of that Island, appears to have existed as a fortress from the earliest times; previously to the coasts being defended the inhabitants were accustomed to retire within its precincts every evening to secure themselves and their property from the attacks of pirates, who frequently disembarked during the night.

The first fort built on the coast of Goza was Miggiaro, situated between Robiglium and Uyed el Rajos. This was erected in 1605, from the fund left for that purpose by the Grand Master Martin Garces. The Bailly de Chambray began to build another, at his own expense, in 1749; but, not being completed at his death, it was afterwards finished by the Order, and called City Chambray.

Most of the other works along the coast appear to have been constructed about the beginning of the last century.

It is to be observed that De Tigné (in 1716)*, who recommends the repair of the works at Citta Vecchia, proposes also that the Castle of Goza should be put into an efficient condition.

*Commino.*—It is said that the necessity of defending the Island of Commino, as well as the Straits which form it, occasioned the University of Malta, in the year 1419, to propose to King Alphonso that a tax should be laid on wine in the Islands of Malta and Goza, and that the money collected should be devoted to the construction of a fort. The tax was levied; but it does not appear that any fortifications were built till the year 1618, when the expenses of their construction were defrayed from the produce of the Island.

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* $\frac{\text{Reports}}{121}$, p. 93.

W. H. T.

# APPENDIX I.

*List of the Grand Masters of the Order of St. John, from the date of the settlement of the Order in Malta.*

The numbers show the order of succession of each Grand Master.

| | | A.D. | A.D. |
|---|---|---|---|
| 42 | Philip Villiers de l'Isle Adam, ... ... | 1521 | 1534. |
| 43 | Peter du Pont ... ... ... ... ... | 1534 | 1535. |
| 44 | Didier de Saint Jaille ... ... ... ... | 1535 | 1536. |
| 45 | John d'Omedes ... ... ... ... ... | 1536 | 1553. |
| 46 | Claude de la Sangle ... ... ... ... | 1553 | 1557. |
| 47 | John de la Valette ... ... ... ... | 1557 | 1568. |
| 48 | Peter de Monte... ... ... ... ... | 1568 | 1572. |
| 49 | John L'Eveque de la Cassiere... ... ... | 1572 | 1581. |
| 50 | Hugh de Verdala ... ... ... ... | 1581 | 1595. |
| 51 | Martin Garces ... ... ... ... ... | 1595 | 1601. |
| 52 | Alof de Vignacourt ... ... ... ... | 1601 | 1622. |
| 53 | Louis Mendes de Vasconcellos ... ... | 1622 | 1625. |
| 54 | Antony de Paule ... ... ... ... | 1625 | 1636. |
| 55 | John de Lascaris ... ... ... ... | 1636 | 1657. |
| 56 | Martin de Redin ... ... ... ... | 1657 | 1660. |
| 57 | Annet de Clermont ... ... ... ... | 1660 | |
| 58 | Rafael Cottoner ... ... ... ... | 1660 | 1663. |
| 59 | Nicholas Cottoner ... ... ... ... | 1663 | 1680. |
| 60 | Gregory Caraffa ... ... ... ... | 1680 | 1690. |
| 61 | Adrian de Vignacourt ... ... ... ... | 1690 | 1697. |
| 62 | Raymond Peirelos ... ... ... ... | 1697 | 1720. |
| 63 | Mark Antony Zondodari ... ... ... | 1720 | 1722. |
| 64 | Antony Manuel de Vilhena ... ... ... | 1722 | 1736. |
| 65 | Raymond Desping ... ... ... ... | 1736 | 1741. |
| 66 | Emmanuel Pinto ... ... ... ... | 1741 | 1773. |
| 67 | François Ximenes ... ... ... ... | 1773 | 1775. |
| 68 | Emmanuel de Rohan ... ... ... ... | 1775 | 1797. |
| 69 | Ferdinand de Hompesch ... ... ... | 1797 | 1799. |

NOTE.—The above list is taken from *Appendix I.* to Major Porter's ***History of the Knights of Malta.***

# APPENDIX II.

*Notes from "Le Devis Général des Fortifications de Malte," by the Chevalier Blondel, Engineer to the Order of the Knights of Jerusalem, 1681: chiefly in so far as it bears on the history of the fortifications.*

[$\frac{\text{Reports}}{120}$, in the War Office, is the original document, which is in French, and contains autograph certificates from Vauban and others.]

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After a short general description of the Maltese Islands, the Chevalier observes that Malta contains seven towns, sixty villages, and 80,000 inhabitants. Nature and art have combined to make the coast inaccessble; all the points which would have been accessible, being guarded by forts and towers of proportionate strength, which see each other, and correspond by signals. No enemy's naval force can winter there.

Blondel then describes the harbours of Malta as follows, viz.:—

*Frioul*, defended by a large tower of that name on the island of Commino, and that of Garcia on the island of Goza.

*St. Paul's Bay*, guarded by a tolerably large tower of that name.

*St. Julian's Bay*, an indifferent harbour, guarded by a tower of same name.

*Marsa Scala*, guarded by the strong fort of St. Thomas.

*Marsa Sirocco*, also guarded by a large tower of same name.

None of the above are large enough to contain an enemy's fleet, or sufficiently sheltered to enable him to winter there.

*Valetta* was built after the design of Laparelli, Engineer to Charles V. The land front is defended by four very obtuse-angled bastions, of which the middle(?) is the flattest; the front is broken by flanks and curtains. The flanks of two tiers, occupied by round orillons, the ditch narrow, but deep; the covered way (?) narrow and inconvenient.

Blondel does not think it necessary to enter into a detailed account of the triple, nay, quadruple additions which have been made from time to time to this front. The original trace was designed by the Marquis de Saint Ange, who had never seen the ground; hence the defects, which no subsequent reforms have been able to remedy. The two great cavaliers in the gorges of the bastions existed in Blondel's time. Laparelli improved St. Ange's plan by the skilful mode in which he carried it out. The whole of the counterscarp was most unfortunately cut down by more than two toises ($12' \, 9\frac{1}{2}''$) owing to St. Ange not having been provided with a section of the ground. The fausse braye was then in existence. The interior retrenchments should be taken away, and their ditches filled in. The ravelin in front of Porte Royale was St. Ange's; and, though double, it was too small.

The Bastion de Vendome and the Jew's Terrace make a re-entering angle which is "dead," small, low, and obtuse; a ravelin should be placed in this angle, also two small demi-bastions; this would strengthen the defence of Marsa Musceit, and also prevent an enemy occupying point Drágut. Some other similar defects of the *enceinte* should be remedied.

*St. Elmo* is small, fortified on the city side by a broken tenaille, like the front of Valetta, but much smaller, with flanks having round orillons, the ditch deep and wide, without counterscarp. The water fronts merely fortified "en étoile," or with simple tenailles, with a ravelin, and raised "en cavalier" on the side which fronts the sea. There is a long gentle unoccupied slope between it and the sea. The ditches and counterscarps on this side are very imperfect, and indeed, scarcely commenced. St. Elmo would easily fall a prey to an enemy, and so afford a point of attack against Valetta. St. Elmo makes the whole of the fortifications weak. The best engineers, including Valperga and Blondel himself, recommend three tenailles on this side, with ditches and counterscarps cut in the solid rock. Valetta requires no citadel like St. Elmo, which may be directed against the city itself; the land front which was built before Valetta was founded should, therefore, be destroyed, and St. Elmo should form simply a portion of the Valette *enceinte*. Houses should be built over the ditches, the latter serving as tanks and stores.

*Floriana.*—This front is the strongest and best part of the fortifications, and upon it depends the safety of Malta; but it should be raised throughout one toise, and in some parts even two toises.

It consists of two large tenailles, with three "Royal bastions," and a fausse braye. The sally-port was formerly covered by a small ravelin, which Valperga destroyed, but which should be reconstructed.

The bastions are retrenched with large "taillades."

The retrenchments of the bastions of the Floriana front are more beautiful than useful, and rather disadvantageous than otherwise; they should, therefore, be removed. Blondel points out many other defects in this front, and suggests remedies.

The bastion Dovern(?) is much embarrassed by the presence of the Capucin Convent, which should be removed.

Blondel gives Florian great credit for the length of his lines.

The *crowned horn-work* is described: it was built at the expense of Jean de Galdeane, Grand Prior of Navarre.

It is too small, improvements are suggested, a retrenchment should be constructed, &c.

The *place d'armes* is the finest in Europe; it is nearly square; at present there is nothing on it but a mall, and a tower in its midst; on the right there are a powder magazine and a windmill; on its left the little Tour-de-lis, and the Church of Nôtre Dame de la Conception, built under a vow made by the Knights during the plague of 1675-6.

There are also one or two other small structures. Florian intended that it should be built over (as Valetta was), and that it should be called Citta Paula, after the Grand Master of that name.

Many engineers have been of the same opinion, and Valperga does not altogether object to it; he having designed three rows of houses on each side.

Blondel is also of this opinion: the Floriana front is of so great importance that every means should be used to induce the defenders to prolong its defence. This would be insured by giving the Maltese something better than a vacant space to defend; and, if occupied by buildings, the besieged would always be conveniently lodged near the works, which could not be accomplished unless this place were, as it ought to be, inhabited.

Unoccupied, it reflects the heat of the sun, and would be prejudicial to the health of the defenders, many of whom would be strangers to the climate; and during a siege it is worse to have sick men about than the dead.

Tents or huts would be inconvenient, or impracticable, and would not be fire-proof, or stand against the strong winds to which Malta is subject.

This space should, therefore, be occupied in the same manner as Valetta is. Details of the proposed mode of occupation are given.

Blondel then proceeds to discuss the relative advantages of wet and dry ditches, and is in favour of the latter for Malta.

*Sanglea.*—Its front is fortified after the old fashion, chiefly by redents, with a small bastion in the middle; flanked on its right by the bastion of the right wing on the same front, which is low and unfinished. Its left is flanked by such defences as could be obtained from the Bourg front, with a demi-lune in the front of its ditch, made in the time of the Grand Master Paul, in the gorge is situated the cavalier of St. Michael. This small bastion is in ruins. The new bastion on the right wing should also be finished and heightened.

The water front should also be improved; especially the middle bastion which remains incomplete, as this is the great defence against an attack from the Coradin heights. He recommends that the interior water line of Sanglea, on the side of the Port of Galleys, should also be fortified.

*Vittoriosa and the Castle of St. Angelo.*—The Vittoriosa front of this castle is fortified by a tenaille, half broken, and half "en puissance," revetted, and very high, its ditch cut out of the solid rock; this ditch being nearly two toises under the level of the sea is full of water, the remainder is environed by ancient and irregular walls along the top of the high scarped rock.

Under the castle, at the mouth of the Port of Galleys, is a fine "à fleur d'eau" battery, which should be repaired and armed. Here one end of the chain across the mouth of the Port of Galleys was fixed.

The enclosing walls should be put in order, and strengthened.

He cannot understand why the two banks of the Port of Galleys have not been provided with flanking defences; as, if the galleys were at any time out of the port, an enemy might establish himself here without much difficulty; this state of things should be remedied.

The exterior sea wall is in good condition.

*The Land Front.*—Its faults are chiefly at the wings on the right; the marine gate, and the whole bastion is in ruins. Blondel furnished a design for its restoration, which was approved in council, and which he describes. The ditch should retain its full size; as being open to the water, it is much used for ship-building purposes, &c.

The celebrated post of Castille is situated on the left wing; it is now dismantled, and in a ruinous condition; its walls should be raised, the breaches repaired, and it should be revetted throughout.

*Burmola.*—The place d'armes should be kept clear. The Burmola houses should not, under any pretext, be allowed to approach any closer than at present, even when the Cottonera lines shall have been completed (see further on Burmola).

*Cottonera.*—Consists solely of an exterior front of eight bastions, and two demi-bastions, which form nine tenailles.

It encloses the two great suburbs of Burmola, and the valley of St. Elena, also the fortification of St. Margaret, and four other large spaces farther out:—1st, St. Jean tal Aloucha; 2nd, St. Elena Valley; 3rd, Nôtre Dame de la Grace; and 4th, Ta Macteitin.

The foundations of the lines are laid throughout.

Its *advantages* are:—1st, that it covers Vittoriosa and Senglea from the points whence they could best be attacked.

2nd. It covers the Port of Galleys (the object for which the fortifications of St. Margaret also were built, but which, however, did not accomplish their purpose).

3rd. It covers Burmola.

4th. It occupies all the strong positions to the front (denying them to the enemy.) The ground slopes gently away in the front, and more rapidly at the wings.

5th. It reduces the number of points from which Vittoriosa and Senglea can be attacked. The facilities for an enemy's attacking this part are lessened by the fact that the right and left wings of these lines rest on the sea.

6th, and last, a still greater advantage, it affords a safe shelter to the country people who may take refuge here in time of siege, and so escape capture, and the horrors of slavery under the Turks.

In time of siege all other parts within the fortifications would be filled with the defenders and their retinues (another strong reason, by the way, for the occupation of Floriana).

Over-crowding in the existing houses would under such circumstances bring on the plague. Wherefore, the Cottonera lines should be finished.

Here follows a short dissertation on the nature of expenditure on fortifications, and the advantages, in respect of garrisons, possessed by the Knights of St. John.

The *defects* are:—1st, that its regular trace is not suited to the irregularities of the surface.

2nd. It has the usual defects of the Dutch system of fortification; the ditches being ill-flanked, and the flanks small and exposed.

3rd. Its members are on too small a scale. Moreover, the lines do not include, as they should have done, two heights, namely, Coradin* and St. Saviour, on which Valperga proposed two works, the former on an ill-chosen site, the latter to unite Cottonera with Ricasoli.

* The Coradin heights were so-called after one of the most famous Generals of the Turkish army. Projects for their fortification will be found in $\frac{\text{Reports}}{\text{264 and 125}}$, by Capt. Dickens, R.E., dated 1805 and 1818 respectively, and also in Colonel Harding's Report, 1804. $\frac{\text{Reports}}{\text{68}}$.

The illustrious engineer Verneda's magnificent idea was, that a front should have extended from the great marse of the Port Royale, a little above Ras-ta-canzie (that is to say, from Mour de Parc, opposite Floriana crown-work), and, after having included all Coradin, passing by St. Margaret's, a little outside the present fortification of that name, would have finished directly on the sea; at which point an irregular line of coast defence would secure this flank, and connect it with Fort Ricasoli.

Blondel thinks that nine "Royal bastions" would have been sufficient for this line.

Of this scheme Blondel speaks in the highest terms of praise.

Unfortunately, however, the Cottonera lines had been commenced; the wall is already as high as the cordon throughout; even the parapet is made in some parts, and the whole of the ditch is nearly half finished.

Since, therefore, it would not do to abandon the works, the following *general* remedies are proposed for its defects :—

1. The cavaliers which Valperga proposed within each bastion should not be constructed.

2. The flanks should be doubled, in the manner already carried out at the demi-bastion of St. Raphael.

His reasons for objecting to the cavaliers are given in detail :— they occupy the bastions, interfere with their defence, and the result of a mine would be that both cavalier and bastion would fall together; their debris would choke up the bastions, they would double the cost of the works, and, finally, when an enemy had once effected a lodgment, would facilitate rather than retard the capture of the place.

3rd and 4th. The ditches should be widened, and rounded at the salients (this reform had at length been authorised, and was in progress).

5. The bastions should be filled in to the gorge.

6. The height of the bastions should be accommodated to the peculiar circumstances of each.

The following detailed suggestions for the improvement of the works are then given :—

A counterscarp, &c., should be formed to St. Raphael's demi-bastion: the salient and right face of St. Antony's bastion should be raised, and a large cavalier should be formed at the gorge of this bastion ;—these reforms being rendered necessary by the presence of the adjacent heights of Coradin, and the new Casal. The bastion of

St. Paul should be completed without delay, by raising the right face and strengthening the flanks. The bastion of St. Jean should also be raised (the cordon here had been unfortunately made during the temporary illness and absence of Blondel.) The right flank of this bastion, and the left of St. Nicholas should especially be strengthened, on account of the St. Elena valley. Valperga's Platée is described as useless. Blondel heightened the bastion of St. Clement eleven or twelve feet beyond Valperga's design. The remaining bastions of Nôtre Dame de la Grace, St. Jacques, St. Louis, and St. Sauveur, and the demi-bastion of St. Lawrence, as well as the curtains connecting them, are now ready to receive their cordons and parapets; indeed, Nôtre Dame has its parapet already made. The flanks of these bastions too should be doubled, their terrepleins and ramparts finished, and the bastions filled in to the gorge. On the left wing, as well as on the right, the ditches and counterscarps must be suited to the nature of the ground, according to the judgment of the engineer.

Blondel proposes two large demi-lunes: one at the salient of St. John's bastion, and the other at St. Louis. No changes are proposed in the ravelins. Traverses should be made for the right and left wings of the lines. The ravelin in front of St. Paul's Gate* should not be executed. Places d'armes should be constructed along the Cottonera counterscarp, and gates should be made in each of the curtains, three of which should be principal ones: 1st, Nôtre Dame de la Grace; 2nd, St. Paul; 3rd, St. Sauveur.

*Burmola or St. Margaret.*—Blondel says, that the first design for the fortifications of St. Margaret was given by Fiorenzuola, a Dominican monk, afterwards a Cardinal; his object being simply to cover the Port of Galleys from the fire of batteries which would otherwise have probably been constructed by the Turks on these heights.

Valperga appears to have intended to build a castle at this point, but did not complete his intentions. It was the Engineer Palavicini who so greatly extended this design, without destroying what had already been commenced. He proposed to enclose, not only more or less of the front of Vittoriosa, but also the whole of the front of Senglea; and, consequently, the populous suburb of Burmola.

Had this design been carried out, it would not have enclosed a sufficient protected space for the country people in time of siege; but would have, at least, served to protect the towns of Vittoriosa

* ? At Burmola.

and Burmola, and the Port of Galleys. The money already spent on the Cottonera lines (which will not be finished for some years) would have been sufficient to complete Palavicini's design. He disapproves of Valperga's design for a castle with gardens, &c., on this spot.

*Ricasoli.*—It gives Blondel much pain and regret to have to describe this work. It is by far too small, and too weak; faults which could easily have been avoided in so fine and important a situation; and, from its extreme smallness, its numerous other faults arise. It had recently been finished after the design of Valperga. The designs anterior to Valperga's were much bolder than his, and better adapted to the site. Its fausse-braye increased its expense, without increasing its strength.

In carrying out the works, Blondel was compelled to make some alterations in the design; especially in the sea front, which, but for these, would have been even weaker than the sea front of St. Elmo. He proposes a ravelin at the point, with a powerful sea battery "à fleur d'eau."

The old tower of Orsa or Santa Petronia was built, at the expense of a Commander of that name, for the protection of the mouth of the harbour. It should be removed.

The lodgings along the front are unnecessary, and very expensive; at Floriana, buildings would be cheap and useful; here they are costly and useless. The counterscarp (?) of the front is imperfect; at sundry places it should be widened. Other additions and improvements are suggested.

Blondel again mentions Valperga's scheme for connecting the left of the Cottonera lines with Ricasoli, and at the same time occupying the heights of St. Saviour; also his project for a work on the summit of the Coradin heights. He then goes on to observe that a work had been designed by Valperga on Isolotta,* in the middle of Marsa Musceit harbour. With respect to the occupation of the heights of St. Saviour, between Cottonera and Ricasoli, he observes that such a work would be badly situated. With regard to the Coradin work its site also was ill-chosen; namely, at the foot of the little hill de la Tour, on which a windmill formerly stood. This hill would command the work, which should rather have been placed a little in front of the old windmill tower itself. Both of these designs were after the faulty Dutch system.

* Fort Manoel.

*Manöel.*—The propriety of fortifying this island is problematical. If carried out, Valperga's design is too small, and too weak. Blondel promises a better design.

*Tigné.*—He is also ready to design a work for Drágut Point.

*Citta Nobile.*—Commonly the Old Town; called by the Maltese M'dina, an Arab word, signifying "Town." It is the most ancient in Malta, and was for many years the only one.

Blondel proposed certain reforms in its fortifications in 1659, which were not carried out, except the foundations of a low bastion between the right and left wings. This was completed without following Blondel's plans. It should be reformed in accordance therewith. It is doubtful whether this place should be fortified at all; but, as it contains the residence of the Bishop of Malta, the Cathedral, Convents, and public buildings, and was, moreover, of considerable service during the siege by the Turks, to say nothing of the miraculous intervention on that occasion of St. Paul himself (its especial protector), Blondel thinks that its fortifications should be maintained.

*Isle of Goza.*—Valperga's scheme for fortifying the Rabato is on too small a scale. The castle itself is old and in ruins; but, if it fell into the hands of an enemy, he might from thence reduce the whole town to ruins.

All engineers prior to Valperga have agreed that the proper place to fortify would be Marsal Forne. It is a cliff which commands the sea, and is not itself commanded by any other point, and it might be easily fortified. It has two small bays adjacent to it, supplied with water beyond the command of the besiegers. At present there is only a tower here on the edge of a precipice, which corresponds by signals with the other towers round the islands.

The neccessary works for completing the fortifications are then summarised in fifty paragraphs; and by carrying out these reforms Blondel pronounces Malta impregnable.

W. H. T.

# APPENDIX III.

## AUTHORITIES.

| | | |
|---|---|---|
| Two Vols. of Italian Maps of the XVI. Century. | $\frac{916}{101 \& 102}$ | British Museum. |
| Lauro's Plan and Description of Malta, in 1636. | $\frac{C.\ 46\ d}{1}$ | British Museum. |
| "Discorso sopra la fortezza di Malta." No. 1 of Harl., MSS. 6794. ... ... ... ... ... | | British Museum. |
| Vertot's "History of the Knights of Malta." Ed. 1728. 483 *e.*, 11-12 ... ... ... ... ... ... | | British Museum. |
| Louis de Bois-gellin's "Ancient and Modern Malta." Ed. 1804. 178 k. 9 $\frac{♔}{10}$. ... ... ... ... | | British Museum. |

Pamphlet on "Malta and its Fortifications." Printed at Malta, 1800. (In R.E. Library). ... ... ... ...

Major Porter's "History of the Knights of Malta." ... ...

Prescott's "History of Philip II." ... ... ... ...

Balbi's "Verdadera Relacion." ... ... ... ... ...

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*The War Office Maps and Reports referred to are specified by their respective register-marks in the course of the preceding pages.*

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NOTE.—The dates and positions of the inscriptions on various parts of the works are taken from plans furnished by Col. Durnford, R.E., on 29th of May and 25th of September 1866, see $\frac{\text{Malta 5}}{1446 \& 1493}$. These plans are now deposited in the War Office collection, and are registered F 180.

## PAPER IX.

### THE

# SO-CALLED THERMAL SPECTRUM.

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

*A Lecture delivered at the R.E. Institute on the 24th October,* 1878.

Before I enter into any serious discussion of the subject I propose to deal with, I must explain why it is I have chosen for it the title of the "So-called Thermal Spectrum." It may be imagined that science demands and gets great exactitude in definitions which fall within her scope. The demand she makes, but in a great many cases she fails to get it. In fact, in all branches of science which have become at all popularized there is a great deal of inaccurate thought suggested and language employed. I need not go beyond the theory of electricity as popularly taught, and I am sure those present will agree with me, that the notion regarding a conducting wire, potential, and of electricity itself, is based on what I may term the water works theory, rather than on sound mathematical reasoning.

The original, and, I may say, the narrow application of the word "spectrum" had reference to the band of colours resulting from the decomposition of a ray of white light by a prism. The present meaning of the term as applied to analysis has, however, become enlarged, and by it is meant the analytical separation of the radiations of different wave lengths, which emanate from a source whose molecules or atoms are in a state of vibration. It is only in this sense that we can use the term "invisible spectrum," as it is an anomaly to talk of light as being invisible, though it is not so to talk of a radiation.

It is a popular notion, to be found even in text-books of the present day, that there are three forces existing in radiations, viz.: heat, light, and chemical action, and it dates from the days when the corpuscular theory of light was held, which made it necessary that some such division of force should be instituted. Since, however, the undulatory theory of light has been established beyond doubt, it is not only unnecessary, but mischievous. The spectrum is composed of an almost infinite number of undulations, all of which convey a certain amount of energy; the ether in which they oscillate, is simply a channel of communication for transmitting that energy from a body, whether close or distant, whose molecules are in a state of agitation, and which is consequently a source of energy. The energy conveyed must be expended as "work done" in the body which absorbs or annihilates the undulations. It may be by causing an increase of the absolute temperature of the body; by chemical action in causing the combination or separation of the atoms composing the absorbing body, or if the absorbing substance be situated in the eye, by causing it to bleach, and thus to give the sensation of vision; or once again, it may be expended by the generation of another form of energy which we call electricity. Light, heat, and chemical action then are simply the *effects* of the energy conveyed in a radiation, and nothing else. This theory seemed to be in a state of tottering equilibrium when it was anounced that the radiometer was acted upon by light as light, more particularly when one great mathematician, whose labours have largely contributed to establishing the undulatory theory of radiation, for a time held this idea; but after all, truth triumphed, and the supposed effects of light were traced to thermal currents.

Now, the portions of the spectrum with which I have to deal are the red and ultra-red, and here the heat rays are principally supposed to lie. They are frequently classed together, and called the thermal end of the spectrum; and the figures obtained by the measurement of the heating effects of the whole spectrum are called the "thermal spectra," or "heat spectra." Both these terms are inaccurate, since what is shown is merely the amount of energy, perfectly or imperfectly absorbed, giving rise to internal molecular movements by an increase in the temperature of the absorbing body, which in its turn may part with some of its newly-acquired energy by causing evaporation of a fluid in contact with it, (see page 3) or by exciting electricity (see page 5).

The first thermograph of the solar spectrum published was probably due to Sir J. Herschel, and his method of procedure was as follows:—

"The thinnest post paper, such as is sold for foreign correspondence, was stretched on a frame, one side of this paper was blackened with indian ink, or, which is better, smoked in the flame of oil of turpentine, or over a smoky candle by drawing it often and quickly through the flame, giving it time to cool between each exposure, till it is coated on the inner side with a film of deposited black, as nearly uniform as possible." The white side of the paper was exposed to the spectrum, in an apparatus which the diagram will explain. It will be seen that the sunlight is received on a lens,

*Fig.* 1.


A, is a flint glass prism; B, a collecting lens, having a mean focus at C; E, the locality of the yellow rays.

thence refracted by a prism, and that the analysed radiations from the optically formed *image* of the sun are received on a screen about one foot from the lens. The position of the yellow ray of the impure spectrum so formed, was fixed by a method which it would be unnecessary to enter into here.*

The spectrum produced by this means was received on the prepared paper, the white side of which was washed uniformly over with good rectified spirits of wine. Herschel says, "after a few minutes a whitish spot begins to appear, considerably below the extreme red of the luminous spectrum, which increases rapidly in breadth until it equals the breadth of the luminous spectrum, and even sometimes surpasses it; and in length till it forms a long appendage exterior to the spectrum, and extends moreover, within it, up to, and beyond the fiducial yellow." He then states that he

* The position of the yellow ray was fixed by examining the spectrum through a piece of cobalt glass, a yellow ray was transmitted, and the prism was so adjusted, that this yellow image of the sun fell on a mark on the screen.

applies "another wash of alcohol, when the thermal spectrum begins to appear in its true character, the drying of the alcohol as shown by the opacity of the paper indicating where the thermal maxima are situated."

In *Plate* I., *Fig.* 1, we have Sir J. Herschel's thermograph, and its general appearance is well shown.

Please to mark that there are regions marked $\alpha$, $\beta$, $\gamma$, $\delta$, and $\epsilon$, which indicate different maxima of heat, the last one $\epsilon$ being, by the bye, very faint. Sir J. Herschel imagined, and I believe correctly, that the absorption of the spectrum at other parts below the red were due to gaseous matter between us and the sun, more especially in our own atmosphere, deriving his opinion from the analogy of the absorption of the luminous rays by nitrous oxide gas.

It was only last year, at the meeting of the British Association, that any doubt was thrown on the correctness of this thermograph of solar radiation. Lord Rayleigh, a physicist whose experiments are carried out with the greatest nicety, and with a full knowledge of all the latest advances that have been made in science, drew attention to the fact, that the existence of the spot $\epsilon$ was improbable, in that it occupied a position which was theoretically outside the limit of the prismatic spectrum. It may not, perhaps, be well known that such a limit to the least refrangible rays does exist. On a cursory examination it would seem to be reached when the index of refraction of a ray is unity, that is, when any number of prisms, if placed in any position along a straight line, allow a ray to pass through them unrefracted. Researches in the higher branches of optics show, however, that this limit can never be obtained, since a factor is introduced dependent on the wave length, and also on the material of which the prism or prisms is composed. Lord Rayleigh found that he got all the thermal spots except $\epsilon$ when using his own apparatus, and he further proved this exception by a different method, dependent on the acceleration of oxidation of iron by heat, where the iron exists in a state as found in a mixture of ferro-cyanide of potassium, and ferric-chloride.* The explanation of this discrepancy seems to be that Herschel used a flint glass prism, with three polished surfaces, and the spot $\epsilon$ *may* have been caused by an internal reflection from one of these surfaces. This limit of the prismatic spectrum I shall again refer to presently. We may, however, accept the thermograph of

* These two solutions were separately brushed on to paper, leaving a greenish tint. When exposed to the solar spectrum, the part affected changed to Prussian blue.

Herschel omitting $\epsilon$ (a spot, I may say, which in my repetition of the experiments I never succeeded in obtaining), and hold it as a standard of comparison with other impressions made by the solar spectrum, produced under the same optical conditions. There is, however, one great drawback to its value, in that the image of the whole disc of the sun was passed through the prism instead of a slice of light, and it is hopeless to draw from it any accurate conclusions regarding the absorption that takes place in the solar photosphere, or in our atmosphere, on account of its impurity.* For a rough method it is, however, excellent.

The next researches, in the same direction, which are attainable are those by Lamansky. He caused a very narrow thermopile, with the face guarded by an adjustable slit, and blackened with lampblack, to travel along a solar prismatic spectrum, and then recorded the deviation of the galvanometer needle produced by the thermo-electric current. His results are given in *Plate* I, *Fig.* 2. A glance at it will show that there are four maxima. The ordinates scale the *relative* heating effects of different parts of the spectrum. The first maximum seems to occur about A, on the visible side of the spectrum, the remainder are somewhat erratic. For the sake of comparison, however, I have shown Herschel's thermograph above this, and it will be seen that the maxima agree fairly well with each other, though there is no trace of any maximum at $\epsilon$. In the memoir of Lamansky, he never alludes to this spot.

I would call your attention to a new method that is being adopted by Dr. Guthrie, for measuring the thermal effects of radiation, and which is much more accurate than the thermopile. He stretches a very fine iron wire, covered with lampblack, vertically between two rigid conductors connected with a delicate galvanometer and battery, and causes it to traverse the spectrum. Even the slightest transference of energy to the wire by radiations causes a change in its resistance, and this is shown by a deflection of the galvanometer needle. Manifestly, this method ought to be capable of detecting the existence of absorption lines of the thickness of the wire in the solar spectrum, or of bright spaces in the spectra of incandescent metallic vapours. I am assured that the method is so delicate that the radiations from

* The spectrum is impure, because the images of the sun formed by each wave length overlap each other. With a fine slice of light sent through a prism, the impurity is almost annihilated.

the eye are capable of causing the galvanometer needle to be largely deflected, the difficulty in obtaining a reading is thus apparent.

At present, Guthrie has not tried the apparatus with the solar spectrum, though next year he hopes to operate on it.

The tasimeter of Eddison would also seem to be an instrument which, in a modified form, could well be applied to the spectrum to obtain values of its heating power, and increased delicacy of measurement would doubtless be obtained. It may not at first sight appear that this delicacy is so very important, yet when the measurements which have hitherto been taken are analysed, its necessity will be seen. Take for instance Tyndall's measurements of the spectrum of electric light. The length of the spectrum was rather over one inch in length, and manifestly, it is almost hopeless to expect to find the existence of lines when the width of the face of the thermopile used was ·03 inches. This space in the spectrum would probably embrace innumerable lines, and the effect of small linear radiations would be completely masked. By spreading out the spectrum to two feet and then using a much more delicate apparatus for receiving the radiations, the means of registering the lines would be increased twenty-four fold. If we examine Tyndall's figure of the heat effect of the radiations of the electric light, as shown by a blackened thermopile (*Plate* II.), we cannot but be struck at the astounding difference in form between it and Lamansky's thermograph of the solar spectrum. Near the lowest limit of the spectrum the slope is more gradual. This may be accounted for from the law that bodies are good radiators of the radiations they absorb. Now, carbon in any form partially transmits the radiations having the greatest wave length, and absorbs them less than those of shorter wave length. It may also be partially accounted for by the width of the pile, by internal reflection of heat in the rock-salt prism, and also by the temperature of the electric-arc being lower than that of the sun.

So far then, the least refrangible part of the spectrum was attacked by, what I may call, the temperature method, that is by converting the energy conveyed by radiation into an increase of temperature in the absorbent body. The question then arises, does this method give a true measurement of the energy conveyed in a certain time by the radiations? The question is met by a very plain answer, it does not, and for this reason. Lampblack, which was used as the absorbing medium is a form of carbon, and, is an almost perfect absorbent for the radiations that are visible, and also for some of the ultra-red radiations, but to many of the long waves, as before stated, it is partially transparent.*

The second means of attack is the visual, and such a method has been attempted by Professor Piazzi Smythe with the solar spectrum. His results are shown on the diagram, [shown], I need not enter into his method of proceeding, as the results he obtained are limited. With all the precaution possible he could only observe lines which answered to the first maximum in the diagram, and there the eye ceased to be impressed; but I have mentioned this method to show that it is open to the observer; and perhaps by means of a fluorescent eyepiece,† which will make visible these radiations, a lower limit may be obtained by the eye than has been by Professor Smythe.

Another method was still open, and that was by causing the radiation to do chemical work, a method which is what we may call the photographic method, and which I have had the good fortune to have been first to attack successfully. In this we have, however, to deal with absorbing bodies different to lampblack; they must be compound substances, and substances the vibrations of whose molecules must be in unison with those of the impacting rays in order that the latter may be absorbed.

Since we here have to deal with molecular physics to a certain extent, we must commence by defining what a molecule is; Clerk Maxwell tells us that a molecule is the lowest number of atoms that will swing together when the material structure of a body is set in vibration by heat. In other words a physicist's molecule is in all probability a conglomeration of the chemist's molecules, which are generally supposed to be composed of the lowest number of atoms of which a compound can consist. It is with the former molecule that we have to deal.

The dynamical theory of heat has taught us the little we know regarding molecules. Attempts indeed have been made to measure the distances apart and the diameters of the molecules of gaseous matter, but as to the size and distances of the molecules composing liquid and solid bodies but little is known. Regarding these,

* If a plate of glass be held under a candle flame for a very short time, only long enough, indeed, to allow a very thin deposit of lampblack to take place, it will be found that light of a brown tint is transmitted, and all the blue rays are arrested. The lower down the scale of wave lengths you go the more transparent does the lampblack become.

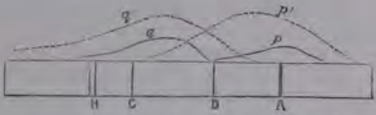
† It is well known that certain dyes have the effect of raising the refrangibility of certain rays. Thus scarlet cloth renders the spectrum visible some little distance below the A line. The action of these dyes is an exception to Dr. Stokes's law, in which it is stated that the refrangibility of the rays is always lowered by fluorescent bodies.

however, we may speculate to a certain extent, from their physical properties; thus, for instance, we may say that the molecules of a substance which is transparent to blue light, or prevents the passage of short waves, are less coarse than those of a substance which allows red light, or long waves to pass through it, since in the one case we have an arrest of long waves, in the other of short waves. After defining what a molecule is, a question arises. Must the molecule for each substance be invariably of the same size, and contain the same number of constituent atoms? Till recently, not very definite opinions were held, though Faraday was the exponent, of the view that the molecular grouping might be infinite, his experiments with gold-leaf seemingly being decisive. Perhaps I may be permitted briefly to describe these experiments, since it is intensely interesting from the point of view which will be considered presently.

I have here a piece of gold-leaf which I hold between the light and the screen, and you see of what an intensely deep green is the light passing through it, though by reflected light it is of the ordinary golden yellow of the metal. Faraday took such a piece of gold-leaf and floated it on cyanide of potassium to partially dissolve it, and thus to diminish the thickness of the leaf. He next placed it on a sheet of glass and heated it strongly for half an hour, when it lost its yellow hue by reflected light and became dead in lustre, whilst by transmitted light it was of a red colour. If, however, he rubbed this thin red-transmitting gold with an agate he found that the lustre re-appeared, and that the light transmitted eventually became of the original green colour after passing through a variety of tints. The explanation that Faraday gave of this phenomenon was that, through the rubbing of the gold, molecules of every size were formed, the change being made visible by the varying colours of the transmitted light. Viewed from the stand point of recent experiment, however, it seems that a different interpretation can be given to this phenomenon. Lockyer has long suspected from his spectroscopic researches that certain phases of absorption he met with, could only be explained on the assumption of the existence of but two elementary sizes of molecules, at all events as far as the visible spectrum is concerned; and recently, he and Dr. Russell have been engaged in isolating some of these molecular conditions with results surpassing their most sanguine expectation. Since his work has not yet been published I am not at liberty to enter into details, but I may say that he has found that all molecules of certain compound bodies which he has examined can be separated into two elementary states of molecular condition; in one there is an absorption of the red end and in the other of the blue end of the spectrum.

The annexed figure will show what I mean.

*Fig.* 2.




Let us take the red molecule first and see how it behaves.

If we have a transparent and thin body composed of these red molecules and allow the spectrum of pure white light to impinge upon it, we shall find that there is an absorption of the red strongly marked about A, which is the visible limit towards the red end of the spectrum, and taking the form of curve $p$; the rest of the light passes freely through. If we increase the thickness of the body, or diminish the intensity of the white light, we shall find that the absorption gradually increases towards the blue end of the spectrum, till it occupies such a position say as $p^1$.

Similarly, if we take the same body made up of the blue molecules, we shall first have an absorption indicated by the curve $q$, increasing as the thickness of the body is increased, or as the light is diminished, till it occupies the position (say) of the curve $q^1$. (D is the position of the absorption line of sodium which lies in the orange of the spectrum.) We are thus led to believe that in compound bodies at ordinary temperatures no great absorption in the yellow takes place, except when both molecules are present and until the curves overlap. Anyone who has looked at a faint spectrum of sunlight, such as of the sky, will know that the yellow is often replaced by green, and that the sodium lines seem to lie in the green. The reason of this may, perhaps, be traced to the existence of only two molecular forms in the "visual purple" of the eye.

Lockyer's definite experiments in this direction were conducted in the spring of this year, and when he informed me of them I was happy to be able to give him another instance of this double molecular condition, a condition, I may say, which I had suspected from this very substance I was experimenting with. I allude to bromide of silver. For the last four years it has been my study to obtain photographic impressions made by those invisible rays of the solar spectrum, which are situated beyond the red. The principle on which my experiments were based was on "the conservation of energy." No body which did not absorb these rays could possibly be affected by them, but even if absorption did take place it by no means followed that the body would be *chemically* altered by the absorbed rays; in fact, it was probable that the only effect of absorption would be an increase in temperature of those bodies. The most feasible mode of attack then seemed to be to use the compounds which were known to respond to the undulations of (that is to be sensitive to) the *blue* rays, and to see if the molecular structure could be so altered that they should absorb the red, for it must be borne in mind that the ordinary photographic compounds invariably absorb the blue end of the spectrum, and are proportionately sensitive to the absorption.

My first attempts were made by weighting the molecules with molecules of foreign substances, such as of resin;* but eventually I discovered a means of increasing the size of the molecules of the silver bromide itself, which, as any of you who may be photographers will know, is one of the principal compounds used in photography. It was found that by boiling the silver bromide in collodion, having an acid reaction, that the red absorbing form of molecule was obtained.

Let me show you this difference of molecular arrangement upon the screen [shown]: Here we have silver bromide in a film of collodion in its ordinary form. You see that it is orange, by transmitted light, and in consequence it evidently absorbs the blue end of the spectrum. Here, however, we have it in its blue transmitting form; notice the blue colour of the film. Evidently we have the red absorbed. Now by mixing the collodions containing these different molecular forms of silver bromide in suspension, we may have any shade of purple by transmitted light, but we never have one which absorbs the yellow, and allows the red and the blue to be transmitted. Another remarkable feature of this blue film is that by friction we get it changed into orange film, as you see here. I may at once state that this ruddy coloured film, whether produced chemically, or by mechanical abrasion of the blue film, proves *insensitive* to the red rays, and to those which lie beyond them, whilst

* See Science Lecture at South Kensington: Macmillan, 1876.

the blue form of film is chemically—to be more popular—is photographically acted upon by these regions of the spectrum. Here then was attained the object in view; the equipment for work was now ready; an equipment, the preparation of which, by-the-bye, has swallowed up months of experiment. I will first of all throw upon the screen a photograph taken with the blue compound on a day when the light was decidedly yellow, and wanting in blue rays; in fact it was taken near sunset. The sun appeared perfectly

*Fig. 3.*

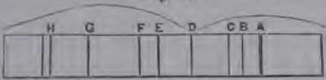



Fig. 3.—The ordinates of the curves at the top of the spectrum, represent the intensity of the chemical action of solar radiation at each point.

golden, and when examined by the spectroscope, was singularly rich in yellow rays. [It must be mentioned that the transparent parts of the photograph through which the light passes, indicate portions of the spectrum in which radiations are absent.] In the photograph we see that the yellow rays produce no effect, whilst the red rays and blue are chemically active; evidently in this case the curves of absorption do not overlap owing to the feeble intensity of the blue end of the spectrum, and consequently, the yellow is only slightly absorbed, and no impression is made by it. This is one of the best proofs I can give you of the existence of the two fundamental groupings of molecules which exist in silver bromide. I must remark that I have never got silver bromide in the state when it absorbed the red alone, though it is usually got in the state when it absorbed the blue alone. I will next throw upon the screen a photograph taken with a prism, on a very different day, and I would

*Fig. 4.*


Fig. 4.—The ordinates of the curves at the top of the spectrum, represent the intensity of the chemical action of solar radiation at each point, and the dotted curves show how the main curve is formed of the integration of two absorption curves.

ask you to observe that the yellow rays are amply impressed. The intensity in the yellow is probably caused by the overlapping of the two intensities due to the red and blue molecules as shown by the top curve in the figure, which is compounded of the two curves drawn beneath it. When the room is again light, I would have you remark how abruptly the spectrum ceases at the lower limit. I have roughly drawn the same photograph to scale beneath the diagram, showing Herschel's and Lamansky's thermographs, (see *Plate* I., *Fig.* 3), and I would ask you to notice the coincidences between the three. They all three agree more or less, any slight variation between them being capable of explanation through the difference of the constitution of the prisms employed. I may say that, in every case flint-glass prisms were used, but, as is well known, the composition, and consequently the refractive indices in different specimens vary materially. Perhaps the most striking feature of the photograph is the fact that it corroborates Lord Rayleigh's views regarding the non-existence of a true radiation near the spot $\epsilon$, in Herschel's thermograph. I firmly believe that, in the diagram of Lamansky's heat spectrum, and in the photograph, we have reached the limit of the prismatic spectrum, which I will now endeavour to show graphically. The diagram *Plate* III., will also show the reason of the particular form that these thermographs take.

The diagram was constructed as follows:—From a photograph taken from a diffraction spectrum, the approximate value of the wave lengths of the different portions of the photograph I have just shown you were calculated, and the true wave lengths were projected as ordinates to it. The last wave length of which I can be tolerably certain, is somewhere about 12,000 tenth millimetres,* and this does not quite reach to the end of the prismatic spectrum, but it will be noticed that the curve, where it ends, is very nearly coincident with the ordinates, and at the last defined point of the photograph it will cut at right angles to the abscissa. The curve also shows the reason why we have these peaks of heat in Lamansky's spectrum; notice the tremendous compressing together of the radiations. Near the termination of the spectrum we might have the radiations of an almost infinite length of the spectrum heaped together, which in the aggregate, might give what Tyndall calls a "Matterhorn" of heat, whereas if the spectrum were spread out into a diffraction spectrum, the mountain would be reduced to a mole-hill.

There is a problem still waiting solution: What are the limits of the *diffraction* spectrum? When we commence to heat a body, are the first radiations emited at the lower limit of the spectrum, or do

* A tenth millimetre is $\frac{1}{10^7}$ millimetres, and wave lengths are always measured on this scale. In subsequent portions of this paper, it must be understood that this scale is used as the scale of wave lengths.

they commence at some definite point, and as the temperature is increased, do the lower as well as the higher radiations begin to appear? Some few experiments I have made seem to point to the latter solution, though it is difficult to see how, theoretically, such can be the case; if it be as I expect, the energy, existing in the lowest part of any spectrum, as well as in the uppermost, will gradually die away. If not, the lowest limit of the spectrum will be bounded by rays conveying greater energy than any other part of the spectrum.

Dr. Draper, of New York, however, argued from theoretical reasoning that the heating power of a diffraction spectrum ought to be equally distributed. I would here call your attention to the property of a diffraction spectrum as we shall have to deal with it presently, viz., that the angle which any ray of the spectrum makes with a fixed direction, is a measure of its wave length. Suppose in one direction we have a wave length of 4,000, and that, in a direction diverging from it 1°, the ray has a wave length of 5,000, then in a direction, having a further divergence of 1° beyond that again, the ray would have a wave length of 6,000, and so on. Draper's idea was, then, that the energy transmitted in the radiations, say between 4,000 and 5,000, was the same as between 5,000 and 6,000. He argued in this way:—"The *vis viva* of any wave of light impinging on an absorbent surface, multiplied by the number of waves falling on the surface in a given time is a constant quantity, therefore the heating power should be the same." As an example we may take a wave of red light and a wave of violet light, the undulations of the latter have only half the length of the former, and the *vis viva* is consequently only half, but in one second the *number* of waves striking the surface would be two of the violet to one of the red, since the velocity of all light radiations are equal. Therefore the heating effect or energy should be equal. In a paper in the *Philosophical Magazine* for August, 1872, Draper describes experiments in which he seemed to prove that this is the case. He divided the *visible* prismatic spectrum into two divisions corresponding to equal differences of wave lengths, and found that the heating effect of the two portions on lamp black, as shown by the thermopile, was nearly equal. He wisely did not touch the ultra red portion, as he was unacquainted with the wave lengths, and he was perhaps not unmindful that lamp black will not entirely absorb these obscure radiations. He was unable to use the diffraction spectrum because of the feeble power it possessed, and hence he was confined to the use of that obtained with the prism. The one weak point in Draper's argument is that he neglects the *amplitudes* of the waves. It by no means follows that the amplitudes throughout the spectrum are equal, and if they are not it vitiates the argument. In fact we have good reason to think that, at all events towards the ends of the spectrum they do diminish.

There is yet another method of indirectly photographing the red and a small portion of the ultra red, a method which Draper successfully pursued in the days of the daguerreotype. A silver plate covered with a thin film of silver iodide (which was produced by exposing the surface of the plate to iodine vapour, as in the ordinary daguerreotype process), if given a slight preliminary exposure to white light, and then submitted to the action of the spectrum, was found to be variously affected. Where the red rays had acted, mercury vapour refused to condense at all, whereas on the rest of the plate where the spectrum fell the vapour condensed rapidly; whilst over all other portions of the plate it condensed very slightly. (This exposure to mercury vapour, I may mention, was the ordinary method of developing a daguerreotype picture). Had the plate received no preliminary exposure the whole of the plate, except where the blue rays had acted, would have been free from condensed mercury. The red, and a few of the ultra red rays had, therefore, apparently undone the work that the white light had performed, and Draper set this down to an *antagonism* of the rays of different refrangibility. With iodide of silver in a collodion film, however, Draper had never been able to succeed in getting the red to "undo" the work done by the preliminary exposure.

It has been my good fortune to have solved this problem which has been awaiting solution almost since the birth of photography, and I also succeeded in obtaining this "undoing" by the red end of the spectrum on iodide of silver held in collodion.

Here we have it:—The collodion film, containing iodide, was slightly exposed to light and immersed in an oxidising solution such as permanganate of potash, and then exposed to the spectrum. The result you see [shown]. My experiments have clearly proved that that there is no "antagonism" between any rays, but that the effect is due to oxidation of the silver molecules whose atoms had been shaken off by the action of white light. From a chemist's point of view this is interesting, as it proves that an oxidised compound of silver is more difficult to reduce to the metallic state than in its unoxidised condition

I have also proved that bodies which are fully oxidised have no reducing action on silver compounds. Here we have a result. On this plate we had a fully oxidised dye, cyanine blue. It was exposed to the spectrum, and became deoxidized. It was then treated with a silver compound, which it failed to reduce except where the deoxidation took place.

I propose now to show you some photographs of the ultra red region of the spectrum, as formed with a diffraction grating, they will enable you to see how little can be known of it until it has been repeatedly and carefully photographed. The peculiarity of this spectrum has already been mentioned, viz., that it gives a measure of wave length to a uniform scale, while a prismatic spectrum does not. The theory of gratings would be too long to enter into, but a simple explanation of it is given in the appendix.

The gratings I have employed were made by Rutherford, of New York, a gentleman famed in scientific circles for these, and for his photographic telescopic work. One was ruled on glass at the rate of 17,280 parallel lines to the inch, and silvered over the ruling; the other on speculum metal at the rate of 8,640 lines to the inch.

I believe Mr. Lockyer has already shown you one of these gratings, but I will venture once again to show on the screen the spectra obtained by it. You will notice that on each side of the central image of the slit of the lantern, spectra are produced, those nearest this central image being called spectra of the first order, the next of the second order, and so on. You will also notice that the violet of the second order overlaps the ultra red of the first order, so that if an attempt were made to photograph the ultra red of the one, we should also show the violet of the other. The first photograph which I propose to show you is a photograph of the first order, and red glass was placed in front of the slit to cut off the violet rays. In attempting to get beyond the limit here reached, I found, however, a difficulty. The red glass, I imagined, absorbed the ultra red radiations, and subsequent experiment has proved that this is the case to a certain degree. To avoid this the plan first used by the celebrated Fraunhofer was adopted. The slit of spectroscopic apparatus was placed horizontally, the light first passed through a vertical prism, and was then allowed to fall on the grating with the ruled lines *placed parallel to the slit*, the prism refracted the different rays in one direction, whilst the grating gave the spectrum in the other. I will show you on the screen a rough photograph of what took place [shown]. You see that all the different orders of the spectra are separated and each one takes a distinct curve of its own, in fact, here are photographs of four different orders on the same plate. This photograph is also illustrative of *Plate* III., as it shows how the red end of a prismatic spectrum is compressed. If the prismatic spectrum followed the same law of dispersion as the diffraction spectrum, we should have the different orders shown as parallel straight bands. It may be as well to remark that, for the same amount of dispersion, the brightness of the diffraction spectrum is very much less than the prismatic spectra. The total useful light for the spectra on each side of the image of the slit is only one-tenth of the light coming into the slit. The brightness of an equal breadth of the spectrum of the first order is about 8 times that of the second order, 27 times of the third order, and so on, the brightness diminishing as the cube of the order used (see appendix). For equal dispersion, the brightness of an equal vertical strip of the visible diffraction spectrum of the first order is only about $\frac{1}{8}$ of that of the visible prismatic spectrum, and in the ultra red the compression of the latter is so great that the intensity soon becomes reduced to the $\frac{1}{50}$ or $\frac{1}{100}$.

For a commencement of work I used the slit of the collimator horizontal, and the grating of speculum metal. This photograph shows what I obtained; notice the grouping of absorption lines and see how symmetrical they are. Where such symmetry exists, we may always suspect them to be due to absorption by compound bodies at a low temperature, in contradiction to absorption by metallic, or elemental absorption at a high one. In my recent experiments in Switzerland with the spectrum, which I photographed at a height of about 7,000 feet, I found that some of these lines had disappeared owing to the less thickness of atmosphere through which the light had to pass, but that a residuum remained, which may be due to vapours of metallic compounds existing in the solar photosphere. This I cannot, however, enter into now, as I have not had sufficient time to discuss my results.

The first absorption line shown, *Plate* IV., has a wave length of about 11,000, or is as far below the limit of red visibility as the line H, or, the limit of violet visibility is above it; so that we have a length of invisible spectrum below the red capable of being mapped in wave lengths equal to the visible spectrum. How much further the spectrum extends beyond 12,000 I cannot say.

The intensity of the absorption lines vary in different photographs, showing that the aqueous vapour exists in the atmosphere in different molecular conditions. Sometimes the whole of this part of the ultra red of the spectrum is absorbed, which is a sure prognostication that the aqueous vapour molecules are getting coarser and preparing to precipitate as rain. A study of these ultra red end photographs of the spectrum, in fact will become a necessity for meteorologists as they indicate changes in the atmosphere, and show the gradual building up or undoing of the water molecules.

To the physicist also, the study of this part of the spectrum will become of increasing importance as there alone he will be able to discuss the question as to what metallic *compounds* exist in the solar atmosphere, for seemingly all *elemental* bodies vibrate in wave lengths which appear in the visible or ultra violet portions of the spectrum, and fail to give lines, as a rule, in the red and ultra red. The molecules of compound bodies, on the other hand, vibrate in unison with the longest wave lengths, which might be expected, seeing they are molecularly heavier than the elements.

I show you a photograph of the spectrum of metallic iron volatilised in the electric arc, you will see that, where the ultra red begins, the lines due to the metallic vapour disappear.

The task which I had before me is now completed, as far as time would allow. I take it that now is my opportunity to apologise for having given a title to my paper which is only half the truth. It might have been called:—"On the methods employed in mapping the so-called Thermal Spectrum;" for in regard to the so-called portion of the spectrum I am afraid I have told but little which is new. In regard to the methods to be employed in mapping it, I venture to think that the photographic method, and the way in which it was arrived at may have not proved utterly devoid of novelty.

When a brother officer addresses you in this theatre it is in general on a subject which will increase your professional knowledge as military engineers. My lecture may not have tended in this direction, but one excuse I will offer for taking up your time, which is that the thermal action of solar radiation has been of use to an engineer in active service. The story of Archimedes and his application of solar radiation to the defence of Syracuse, is too well known to need repetition.

W. DE W. A.

APPENDIX.

# THEORY OF THE DIFFRACTION GRATING.

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It will be well to consider first of all the effect of interposing any aperture between the eye and the light radiating from a point.

Let us suppose AB (*Fig.* 1, *Plate* V.) to be the aperture, and that the light proceeds from a distant point, and is monochromatic. Then the whole of AB may be supposed to be equidistant from the source of light. Draw BC perpendicular to AB, and on AB construct a right-angled triangle, so that BDA is a right angle, and BD equal to one wave length $l$ of the monochromatic light. When the light reaches AB the whole front of the wave will all be in the same phase, since AB is equidistant from the source of light, and consequently, it will proceed in the direction BC unaltered. Now, any large wave at any instant may be considered as made up of any number of small waves, all having the same phase. Let us consider what would be the case when the grand wave reaches AB, and let us examine what will occur in the direction BE. The front of the wave in that direction will lie along AD, and the part at D will be just one wave length ahead of that at A. The phases of the wave will be different at every point, but they will be negative on one side of the central point F of AD, and positive on the other, and these phases when collected together by the eye will exactly neutralize one another. There will, therefore, be no amplitude for the grand wave along BE, and, consequently, no light.

If BD (*Fig.* 1, *Plate* V.) be any multiple of $l$ we shall have the same result, and in the directions thus indicated we shall have no amplitude and consequently, no light.

It may be convenient here to point out a method of looking at the phase of a wave which will convey a graphical idea to the mind.

If we take any particle set in motion by a wave, we know that it describes an elipse, which, for our purpose, may be considered as a circle.

When the particle starts from P (*Fig.* 2, *Plate* V.), and travels along N to M, the phases may be considered positive, and when from M along Q to P, as negative; evidently then, if one particle is attempting to move along PNM, and at the same time along MQP, the combination of the two motions will cause the particle to remain stationary at O, the centre.

If BD be any intermediate length we shall have a different result. Take for example BD $= \frac{1}{2} l$. Then at F we shall have $\frac{1}{4} l$ as the difference between it and A and B respectively. Let us consider the phases at A and F. Suppose at one instant a particle at A occupies the position P (*Fig.* 2, *Plate* V.), then the particle at F being $\frac{1}{4}$ wave length would be in the position N. The mean of the two amplitudes would be unaffected till the particles occupied the positions N and M respectively, from which point till the particles occupied the positions Q and M they would tend to more or less neutralize each others motions, in a similar way the effect might be traced till they arrived at their original positions. *Fig.* 3, *Plate* V., will give a different method of compounding two wave motions, by which it will be seen that the wave length is unaltered, but the amplitude is decreased or increased.

If we take any other points in the front AD, equidistant from A and F in the same direction, we shall find that we get the same amplitude. Hence, we may deduce the fact, that by knowing the amount of retardation in the wave at A and F we can at once find the resultant amplitude, and the phase of the resultant wave is always the same as that of the small wave issuing from the centre.

Now suppose we place bars in the aperture AB, which would answer to the ruling of a piece of glass forming the grating, and for the sake of example let us place four equal bars in *Fig.* 4, *Plate* V.

If we examine the light in the direction BC, we shall find that the same reasoning applies as in the former case, but that the total amplitude of the waves will be diminished by the breadth of the bar to the breadth of the bar plus the small aperture, or $\frac{a}{a+b}$, if $a = \mathrm{A}b$, and $b = bb^1$.

In the direction BD, as found by the method employed in *Fig.* 1, we should also have no light, since the waves would be placed symmetrically around the central point F of the same figure; and this same would occur till in the case of four bars BD the wave length projected $= 4l$. Here we should find that a first *maximum* was obtained; for the waves issuing from the same apertures would all be in the same phase, though if were no bars the resultant of the phases would be nil, but since there are bars to cut off portions of the wave there will be a considerable resultant amplitude for the whole of the waves along AB. If BD $= 8\,l$ the same result would occur. Suppose BD were only $3\,l$ and $7\,l$ (or $5\,l$ and $9\,l$), it will be seen that phases would destroy one another, though between these directions there would be light, but light of very feeble intensity, a point which we shall almost immediately consider. If we increased the bars to $n$, evidently the directions of the maxima would be some multiple of $nl$. The first maximum beyond the principal direction BC is called that of the first order, the second maximum that of the second, and so on. So, finally, we may say that the diffraction images depend on $m\,n\,l$, where $m$ is the order. Thus a line of light looked at through a ruled aperture would be represented by the central image, with faint secondary images vanishing on each side, then again increasing in brilliancy till a maximum was obtained, then dying away again, and so on.

Now, as to the brightness of the side images round the central image or round the principal maxima, we must enter into a little calculation. It has been shown that the resultant amplitude of a series of small waves is that of the middle of its front. Now, since each small wave completes a very large number of whole phases to cause the impression of light, we may calculate the amplitude of the wave by taking the central wave at its maximum phase, and placing the other phases symmetrically round the circle, and integrating all of them to get a mean. Let BC (*Fig.* 5) represent the total amount of variation in phase of all the waves coming through the aperture (that is, let BC represent the retardation of the phases of the waves at each side of the aperture). The amplitude of any point D is represented by DE $= \cos.\ \theta$.

The mean amplitude will therefore be

$$\int_{-\frac{p}{2}}^{+\frac{p}{2}} \frac{r \cos.\ \theta\, d\, \theta}{r\, p} = \int_{-\frac{p}{2}}^{+\frac{p}{2}} \frac{\cos.\ \theta\ d\ \theta}{p}$$

where $p =$ the arc BC (for $p$ is a measure of the angle, and also of the length of the arc)

$$\therefore \text{ the amplitude is } \frac{\sin. \frac{p}{2}}{\frac{p}{2}}$$

Now as the brightness depends on the square of the amplitude (see *Airy's Undulatory Theory of Optics*), it varies,

as $\dfrac{\sin.^2 \frac{p}{2}}{\left(\frac{p}{2}\right)^2}$.

To find when this brightness is a maximum, we need only consider the maximum values of the amplitude,

$$\text{that is } d\left\{\frac{\sin. \frac{p}{2}}{\frac{p}{2}}\right\} = o$$

$$\text{or tan. } \frac{p}{2} = \frac{p}{2}$$

Whence we find that the maxima are situated in directions where $p = o, \left(\frac{2}{3}\pi\right)^2, \left(\frac{2}{5}\pi^2\right)$ etc., nearly the latter values being derived from an expansion of tan $\frac{p}{2}$.

Hence, substituting these values for $p$ we shall find that the side images vanish in brightness very rapidly, even the first image on each side of the central image being excessively faint. It will be seen that this same proof is applicable to the images on each side of the principal maxima. So, practically, we may say that a line of monochromatic light looked at through a ruled aperture will consist of very narrow bands seen in the directions of all the principal maxima (the distances being dependent on the central distance of one bar from another), being brighest in the centre, and fading off to darkness.

We have already seen that the effect of the ruling is to diminish the brightest central image in the ratio of $\left(\frac{a}{a+b}\right)^2 : a^2$. The brightness of the other images must also depend on the ratio of $a : a + b$, since we have seen that if all the small apertures were clear of bars the phases would neutralise one another. We must remember that the whole of the phases of a complete wave is represented by a passage from $o^\circ$ through $\pi$ to $2\ \pi$. For the first maximum the central wave would accomplish one complete motion, whilst the second accomplished two, the third three, and so on, so that $p$ becomes $\frac{m\ a}{a\ +\ b}\ .\ 2\ \pi$, where $m$ is the order of the maximum,

$$\text{and} \therefore \frac{\sin \frac{p}{2}}{\frac{p}{2}} \quad \text{becomes} \quad \frac{\sin. \frac{m\ a\ \pi}{a\ +\ b}}{\frac{m\ a\ \pi}{a\ +\ b}}$$

The brightest image is given where the amplitude is greatest; that

$$\text{is when} \quad \sin. \frac{m\ a\ \pi}{a\ +\ b} = 1 = \sin. \frac{\pi}{2}$$

$$\text{or when } 2\ m\ a = a + b$$

When $m = 1$ this occurs when $a = b$, that is when the bars equal the apertures in breadth. When this is the case, the brightness of the other maxima are given by

$$B_m = B\ \frac{1}{m^2\ \pi^2}\ \left(\sin. \frac{m\ \pi}{2}\right)^2$$

where B is the brightness of the central image, unimpeded by bars. The even numbers of $\pi$ vanish. A grating, therefore, resolves according to the order of maximum used, and also according to the number of lines ruled in a given space.

Hitherto we have supposed the light to proceed from a theoretical line of light, but a physical line must have breadth, and owing to the increased dispersion of each spectrum, the images at the principal maxima will be of greater breadth than the central image, and, therefore, their brightness will be further diminished. They must evidently be multiplied by the factor $\frac{1}{m}$

We have next to consider on what the resolving power of a grating depends, that is, what closeness of lines can be separated from each other.

Let us assume $l$ as one wave length, and $l^1$ as the length of wave close to $l$.

The directions of the maxima for the last would be $m\ n\ l^1$. If this maxima fall in a direction where the first minima of the side images of the first wave length falls, we shall have a resolution of the two waves. The direction of these minima we have already shown is when it is $(m\ n\ l \pm l)$. Taking the positive sign, if $l^1$ be of greater length than $l$, and the minus sign if it be less we get

$$m\ n = \frac{l}{\pm l^1 \mp l}, \quad \text{or if } \delta l = l^1 - l,\ \frac{1}{m\ n} = \frac{\delta l}{l}$$

The calculations regarding the resolving power of a grating may now be easily performed.

In the foregoing paper it was remarked that the violet of the 2nd order of the spectrum overlapped the ultra red of the 1st order. The reason of this will be seen, if it be remembered that the wave length of the H line is only half that of a part of the ultra red, and also that in the invisible violet the wave lengths are so short that when doubled they would give the wave lengths occupying positions far into the visible spectrum of the order of less magnitude.

It will be noticed that the above investigation applies only to gratings through which light is transmitted. A modification of the theory would be required for gratings in which the light is reflected—the principal difference that would be brought out would be the greater brightness of the spectra of the latter over the former.

[Lord Rayleigh has treated the theory of the diffraction grating in a similar manner to the above, involving rather higher mathematics.—W. DE W. A.]

## PAPER X.

# ENTRENCHED CAMPS IN PRUSSIA.

*Translated from the French,*

BY CAPTAIN R. C. T. HILDYARD, R.E.

The following Notes are taken from the *Révue Militaire Suisse*, which itself extracted them from the *Rivista Militare Italiana*.

SINCE 1871, Germany has not undertaken the construction of new fortresses, but she has turned all her energies to the adaptation of existing ones to the present requirements of military science.

The entrenched camps have accordingly a development depending on the number of troops allotted to them in the scheme adopted for the defence of the country. It is assumed that the detached forts of the first line must be sufficiently advanced to prevent all bombardment of the town they cover, or of any part of that town. The distance between the enceinte, and these detached forts, varies from 4,300 to 7,500 yards, while the lateral interval between the forts varies from 3,300 to 4,400 yards. Acting on the now admitted principle, that the main defence, whether in field or fortress warfare, must be in the first line, the Germans assign to their detached forts a most important rôle, and are seeking consequently to increase, by every means at the disposal of modern art, their offensive as well as their defensive power. This last is based not merely on the ditch, which constitutes the real obstacle, nor on the strength of the parapet covering the defender, but also largely on a good disposition of the ramparts so as to diminish the effect of the enemy's fire on men, materiél, and stores, and to offer sure shelters during the whole duration of the defence.

The following are the principal details of the system :—

Relief 26 feet.

The rampart, divided into two levels connected by a gentle ramp, has a total width of 43 to 46 feet.

The thickness of the parapet varies from 23 to 26 feet. The height of the crest above upper level of the terreplein is 7 ft. 10 ins. The depth of the ditch measuring from the top of the masonry counterscarp is 20 feet, the width at bottom is about 40 feet, including the thickness of the detached scarp wall and the chemin de ronde behind this wall.

The scarp is unrevetted, and stands at the natural slope of the soil.

The height of the detached wall placed in front of the scarp is determined by a plane passing through the crest of the glacis, and forming an angle of 15° with the horizon.

In the majority of the forts there is no covered way. The crest of the glacis has a height varying from 6 ft. 6 ins. to 9 ft. 10 ins. There are counterscarp galleries only in those forts provided with countermines, and further, these galleries are placed only in front of the salients, and at the angles of the counterscarp.

The ditch is defended by caponniers, placed in front of the salients, and at the shoulders of the flanks. Smooth bores of 8 or 9 centimetres are used for the defence of the ditch of the fronts, 2 guns to each front. The ditches of the flanks are usually defended only by musketry fire. Gatlings are not yet, and perhaps never will be adopted in Germany. The front caponnier is reached by an earth-covered gallery coming direct from the ditch of the gorge. This gallery follows the capital of the work, and passes right under the rampart of the front: entrances formed near this latter, and near the gorge retrenchment place the gallery in communication with the body of the fort.

The caponniers of the flanks are reached by ordinary posterns.

Besides casemated traverses on the terreplein and expense magazines for the daily consumption, the fort contains further numerous bombproofs for the men, and for stores for the supplies of the fort and of the attached batteries. Care has been taken to give to the forts forms which are little marked, and to avoid all those which are easily visible from a distance, or which would give assistance in aiming at the gun emplacements behind the parapets. Thus the traverses rise above the parapets only to the height necessary to protect the guns, whose genouillères are kept as high as possible in order to avoid deep embrasures.

The number and distance apart of the traverses depend on the extent to which the faces are exposed to enfilade fire. As a general rule there is one traverse to every two guns. The traverses contain casemates which afford shelter to the two gun detachments. There is no cover on the rampart for the armament, which it is intended to withdraw into the attached batteries in case of the enemy's fire gaining the upper hand. There is a shell recess in the parapet for every two guns.

The expense magazines, containing the daily consumption, are formed in the rampart; they comprise:

1. Powder magazines.
2. Stores for loaded shell.
3. Shell filling rooms.
4. Small stores for fuzes and other dangerous explosives.

Magazines Nos. 1, 2 and 3, are made of two sizes, the smaller to contain a supply for 24 hours' fire—for from 5 to 10 pieces, the larger, the same—for from 10 to 14 pieces.

1. *The powder magazines.*—These are built on the interior slope of the terreplein, and are entered directly by a lobby. The internal dimensions of this lobby are 4′ 7″ × 8′ 3″ (along the crest line). The dimensions of the large magazines are 8′ 3″ × 12′ 10″, those of the small 8′ 3″ × 8′ 3″. The height at the crown of the arch is 9′ 3″, at the springing 7′ 3″. If these magazines are built under a face of the work, the internal space is covered by a full arch, of which the springing is placed at the level of the foundation. They are then surrounded by a thick wall, in which there is left a ventilating gallery. The entrance is defiladed by a traverse, which serves also as a parados to the batteries of the flanks, these latter are reached by a special postern. The large magazines have their greatest dimension parallel with the crest line, the entrance is formed in a relieving wall. The powder magazines formed under the terreplein communicate directly with a casemated traverse.

2. *Shell stores.*—These are made to contain hollow projectiles of all natures, also case shot of which there is a supply specially reserved for use in repelling an actual assault; further they are to contain hand grenades, light balls and other sundries. The small shell stores are 12′ 3″ long by 9′ 2″ wide, the large ones are 14′ 9″ by 12′ 3″. The height under the crown is 8′ 3″, at the springing 5′ 2″. They are built close by the shell filling rooms, and communicate with the rampart by steps which lead out under the cover of a casemated traverse.

3. *Shell filling rooms.*—These must be well lighted, they are built on to the interior slope of the terreplein, and have two windows in the rear wall. They have the same dimensions as the adjoining shell stores; the partition wall between the two has an opening 2′ 6″ wide by 2′ 2″ high, through which the shells may be passed.

The loaded shells are brought to the level of the batteries by elevators, fitted in shafts communicating with the ramparts. The shafts start from the lobby, or from the interior of the shell stores, and lead into a casemated traverse. The shaft 4′ 2″ by 2′, is divided by a wooden partition into two equal and nearly square sections. In either of these is placed a sheet iron case, the pair being connected by a rope passing over pullies at the top of the shaft; the projectiles are raised in these cases, the one ascending as the other descends; they are kept in position by 8 runners at the corners, which work against 4 vertical guide rods placed in each section of the shaft.

4. *Small stores.*—These are specially designed to contain explosive stores, such as friction tubes, time and percussion fuzes, &c. They are isolated from the other magazines. There is one to each fort, the dimensions being 6′ 2″ × 4′ 1″.

*Blinded powder magazines.*—In detached works, which cannot easily draw on the grand magazines of the place, there exist, in addition to the expense stores, powder magazines containing a supply for 14 days, and with a capacity of from 10 to 25 tons. (The French tonne is 1000 kilogrammes). The position of these magazines depends on the form of the ground, but they are usually placed behind the gorge of the fort, where they are protected by a sort of redan which is placed in front of the curtain. Their construction is very strong, and in the main walls there is provided a ventilating gallery; on the outside the masonry is covered by a thick layer of soil.

*Shelters for the Garrison, &c.*—There exist in the forts shelters for the whole garrison. Those destined for the guards of the ramparts and for the gun detachments are placed under the traverses, those for the men not on duty, either in the fort or in the attached batteries, are usually placed under the front of the gorge. They are in two floors, extending along nearly the whole length of the curtain, and form very comfortable rooms, whose largest dimensions run at right angles to the front of the curtain.

In addition to the accommodation already mentioned, some of the detached forts are also provided with special stores for Artillery and Engineer matériel, with commissariat magazines, sick wards, officers' quarters, stables, &c.

All the forts, without exception, are provided with drinking water, kitchens, canteens, and latrines.

*Attached Batteries.*—These form an integral part of the fort, and are built in time of peace. The shelters under the traverses, the shell stores and powder magazines are usually of timber, and their construction is put off till the time when the place is put into a state of defence. The attached batteries are placed on the flanks of the forts, and their ditches communicate with those of the gorges of the forts; their crests make a right angle with the capitals of the forts. In each battery there is space for an armament of six guns. Their relief is limited, and is regulated by the necessity of withdrawing the pieces from the effect of the enemy's fire, and at the same time of retaining for them a grazing fire. For every two pieces there is a traverse, covering a shell recess dug in the parapet, and giving shelter to the gun detachments. Each battery has also a special store for loaded shell, and a powder magazine which is placed on the flank removed from the fort. These batteries are closed by a palisade, and the guns in the flanks of the forts effectively sweep the ground in their front, and protect them from open assault.

*Intermediate Batteries.*—While the forts and the attached batteries are intended to oppose the batteries of the first position, which an enemy must take up at a distance of 2,200 or 3,300 yards from the line of the forts, the intermediate batteries are destined to oppose the construction of the batteries of the second position, which the enemy will seek to take up at a distance of 2,600 yards, and also to prevent the opening of the first parallel. They have the character of field works, and are built during the siege, their number varying with the ground and the strength of the two combatants. They resemble the attached batteries, and are armed, as a rule, with six guns. The height of the epaulement is 7′ 10″, of which only 4′ 7″ is above the level of the ground, the remaining height of cover being obtained by sinking the floor of the battery. For the defence hasty infantry trenches may be established.

*Batteries of Position.*—This name is given to small forts, closed at the gorge, which are already built in time of peace, to sweep ground which the forts themselves do not command. These works should be able to resist an open assault. Their ramparts differ little from those of the forts already described.

*The Body of the Place.*—Since 1815, the German Engineers have adopted the ideas of Montalembert and Carnot, that is to say, the polygonal trace more or less modified. No new continuous ençeinte has been constructed in Germany since 1870-1. In the fortresses of Metz, Strasburg, Mayence and Coblentz, the old ençeintes have only been modified in detail. The fortifications of Cologne will offer the first example of the way in which the German engineers read the problem of organizing the ençeinte of a great entrenched camp. The new ençeinte of Madgburg, commenced before the Franco-German War, shows great simplicity of trace. The caponniers are placed at the salients, so that each one can sweep two faces. Those intended for artillery defence are built with two lines of fire, each stage containing three pieces, of which two sweep the ditch proper, one the chemin de ronde. The counterscarp is in masonry and has galleries organized for reverse fire as well as for mine warfare. The scarp is in earth with a detached wall. The relief of the body of the place is moderate, the ramparts are organized in the same way as those of the detached forts, that is as to traverses, magazines, stores and cover for the garrison.

The concluding remarks are taken from Notes of Colonel H. A. Smyth, R.A., written in 1876. The Germans in designing the detached forts, by means of which they are converting their old fortresses into the entrenched camps, or strategic pivots of the present day, keep in view, as the main consideration, the general military requirements of the situation. Thus, at Posen the original plans were altered in deference to the views of the General Commanding the fortress, who objected that the line of defence was too extended for the force which might be expected to be available, and that the task of this force would be unduly aggravated in such matters as the system of guards, outposts, reliefs, communication and superintendence. Accordingly some of the more advanced forts were brought in, from 1000 to 2000 yards, nearer to the place, in spite of the fact that other advantages were thereby abandoned. Great stress too, appears to be laid on maintaining the mobility, and consequently the active strength, of the defending force; a circular road will connect all the forts, running, as directly as may be, just in rear of them; a girdle railroad will pass round between this and the body of the place. Radial roads and railroads will run to the individual forts, and telegraph wires will be laid from each of them, underground, to the centre and to its fellows.

At Posen the line of defence, even when reduced as just mentioned, still measures 20 miles, and Colonel Smyth estimates its necessary garrison in time of war at not less than 30,000 men.

R.C.T.H.

# PAPER XI.

## ON THE

# FIRE OF INFANTRY AT LONG RANGES.

By Baron Seddeler.

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*Translated by Major-General Bainbrigge, R.E.*

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In the *Militar-Sammler*, published at St. Petersburg in May 1878, there is an article on "Practical results to be deduced from our last war" by Baron Seddeler, who was present at the battle of Gorny-Dubnik—and the editor of *Streffleur's Austrian Military Magazine* gives us the following extracts from it:—

The Turks, when they provided their troops with rifles which carry 3000 paces and fire at the rate of 15 shots a minute, determined that the new weapons should be made use of so as to derive the utmost benefit from them, and whilst they arranged for proper supervision of the firing they also paid great attention to measures for avoiding the serious danger of a failure of ammunition likely to arise from their use. They not only provided enormous quantities of cartridges but strove by every means to give the troops in action a constant supply of them. They did, certainly, what is very unusual, for we found in their trenches, and often in open positions, great heaps of cartridges; and we saw behind their attacking troops numerous ammunition cattle. The author, comparing the Turkish Army with the French Army in 1870, comes to the conclusion that the present supply of cartridges is insufficient, and considers the following regulations necessary:—

1. Every soldier ought to carry 105 cartridges.
2. It is necessary most carefully to consider how he can carry the cartridges, and, until other means are decided on, 45 must be carried in the havresack.

3. At present each man carries 60 cartridges, and each ammunition waggon carries about 14,000; of these there are 12 with every regiment of 16 companies, and, if we reckon 150 privates in each company, we have thus 70 cartridges for each man, making a total of 130; but experience shews that this number is not sufficient, considering that only one ammunition waggon per battalion goes into action, and that thus only 83 cartridges per man will be provided. It is necessary to have a supply of 200 cartridges per man actually with the troops, viz., 105 carried by each man, 70 in the ammunition waggons, and the remaining 25 for each man carried on pack animals in bags. The advantage of the latter arrangement is very evident.

4. The orders for the movements of the ammunition waggons should be thus amplified. They must be emptied in turn, and sent back to the spot where the train is ordered to be placed, from which full ones must be brought to the front instead without delay. The pack animals, with two men to each and at the rate of two per company, must follow close to each company, but must not stand close together. The Commanding Officer must see that the men are provided with cartridges, and that the animals are sent back to the waggons for more.

The author goes on to relate that at Gorny-Dubnik the Russians lost men by bullets fired at a range of 3000 paces, that their loss was considerable at 2000 paces, and that when they got nearer such a number of bullets were showered upon them that no one who had not experienced it could imagine the real effect of it. The greater part of the Russian army took the field with Kruka rifles, and it is well known how inferior they are to the Turkish, but this inferiority would have been more perceptible if the enemy had not preferred to remain on the defensive.

From these facts the author deduces the following conclusions.

The superintendence of the musketry fire in the field is not at present sufficiently complete to meet the requirements of quick-firing rifles. Firing at long ranges must be considered by every description of infantry as a particularly effective fire, suitable even for the field.

The aim at objects, sometimes most unfavourably placed on modern battle-fields, must often be taken in a hurry, in order to shower upon them a quantity of bullets. The application of this kind of fire, even against invisible objects, is not without importance.

The rule that firing should be careful and slow will not now suffice; it must be modified by considerations as to whether, on account of special circumstances, a different sort of firing is not sometimes required.

The author finishes with the following suggestions :—

The management of the firing demands special attention, and the officer in immediate charge of it should be made responsible that not a shot is fired without his knowledge or his order. The instruction in firing should be developed to the utmost, especially with regard to the proper superintendence of it, and with this object, a special school should be established, in which not only young officers, by turns, but captains and staff officers should be taught. The instruction in target practice must be brought into consonance with the new requirements in the field, and the men must be taught the rules for firing at long ranges.

The division of battalions into companies of marksmen and companies of the line must be given up, since a good aim is now the chief thing required of the *whole* of the infantry.

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*Note by the Translator.*—Officers of Engineers may deduce from this, the latest experience of the effect of breech-loading rifles, that they cannot be too careful in placing works of defence so that the infantry in them, as well as the artillery, may command as fully as possible a space of 3000 paces in front and flank, and so that no hollows or sinuosities of ground exist which are not swept by fire, or inundated to prevent an enemy obtaining cover in them for attack, even at the distance of a mile. It is also very necessary to make sure that the position of works is such that from their *crests* the ground in front can be swept, and not to rely upon a view taken upon horseback, and therefore from a much higher level. The provision of cover for ammunition animals in rear of positions is likewise shown by this paper to be necessary, and it is very evident that, if it is desirable to have so many animals for carrying cartridges so that the fire of musketry may be commenced at long ranges, it is indispensable to have *plenty of tools* also carried on animals, so that they may be always ready in the front line, to enable infantry rapidly to cover themselves against even distant rifle-fire. (See paper "On Entrenchments" in *Occasional Papers*, vol. ii.).

P.J.B.

# PAPER XII.

## ON THE

# EMPLOYMENT OF THE INFANTRY SPADE.

BY CAPTAIN VON BRUNNER,

*Translated by Major-General Bainbrigge, R.E.*

In an article with this title, in *Streffleur's Austrian Military Magazine* for February, 1878, the execution of field works is discussed from the point of view of the officer of infantry, and it is assumed that a very great number of "spades" are provided for infantry, and of course a proportionate number of picks also, because the necessity for fortifying fields of battle under all circumstances is now universally acknowledged, and, the Engineers being obliged to devote so much attention to fortifying the *key-points* of the positions, the general and simpler work of protecting the troops must be done by infantry in future.*

Infantry must now be rendered capable of executing every kind of work which is required for the security of each separate body of troops alone, *i.e.* cover for its skirmishers and their supports, clearing the ground in front, improving existing cover and rendering it convenient to fire from. All that is required to cover the artillery must be done by themselves or by the engineers, in fact each body of troops must be prepared to form cover for itself as far as possible, without relying upon others to do this.

The following extracts convey the ideas of the author, and may be useful in shewing how much knowledge of details, as well as of the principles, of tracing trenches for defence may now be expected from officers of infantry.†

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* See note at the end.

† The latest experience, especially that gained at Plevna, must convince all officers of infantry that success in holding positions will hereafter depend greatly on setting to work to form cover *as soon as possible*, with the consciousness that their men will often find that they must dig or die.—P.J.B.

The works to be executed by infantry for their own special protection consist of separate rifle-pits, trenches for compact bodies of troops to fire from, and mere shelter trenches * to afford cover and communication but not intended for defence. The smallest trenches, with parapets 19 inches high, only admit of the defenders kneeling, the larger ones admit of their standing, having parapets about 3 feet above the level of the soil. By adding on the top of the parapet, between each man's rifle and the next, "bonnets" or merlons 9 inches higher, leaving hollows between to fire through, experiments shew that great protection is afforded to their heads.

It is generally better to construct the larger trench, because the fire from it sweeps the ground in front much more effectually than that from the low parapet, and it is better to admit of men standing, especially if the bottoms of the trenches are wet and if an assault is likely: and it is generally well worth the labour to transform the smaller trench into the larger if there is time. Wherever there is grass, if each digger begins by cutting out two sods a foot square, laying them at the rear until he has formed his parapet, and then placing them on it so as to form a loophole with sloping sides between the bonnets, he can obtain sufficient cover to enable him to aim carefully without unnecessary exposure. The level of the point over which the men fire should be 4 feet above the bottom of the trench, to allow of the required depression if the ground in front is lower.

The infantry should no longer be satisfied with digging mere "shelter-trenches" everywhere; they will often want good parapets. One great object of digging trenches and forming parapets is to afford cover to *lines of troops* which require to be placed in positions which would, without them, be exposed to an enemy's artillery fire, for they then require much more protection than lines of skirmishers.

The ordinary slight parapets will not afford protection against the enemy's solid shot, and shells will pass through them and explode inside, so that a prolonged artillery fire would annihilate continuous lines of troops unless they have thicker parapets in front of them.

Supposing that the main line of troops is posted on ground high enough to command that in front of the position, and a battalion or wing has to defend a projecting spur, or knoll in advance, so as to flank the position to its right and left, both these positions require parapets giving greater protection against artillery fire, and the

* Schützen Gräben are trenches for defence.
Schutz Gräben are only for cover.

advanced one may often be advantageously occupied by a work secured against assault by enclosing its gorge and by abatis, &c.

The portions of the main position which flank the approach to this work also need thick parapets. Parapets of less thickness will suffice as screens to troops in other parts of the position where they are more scattered, and slight zig-zag trenches may be advantageously formed if there is time, to enable reinforcements to reach the advanced post without being seen by the enemy's artillery, and also to facilitate the removal of the wounded.

Of course, trenches should be traced if possible so as to avoid being enfiladed, but if the enemy can enfilade them with artillery it will sometimes be desirable to form high earthen traverses at intervals, and this may be done by digging two trenches extending about 15 feet towards the rear of the main trench and about 10 feet apart, the earth from which is thrown on to the space between them and piled up as high as possible; the ends of these trenches may be connected by a short one to complete the communication and afford earth enough for the traverse. If there is time to thicken the parapet a small ditch may be dug along the exterior, and the earth thrown out so as to make it more capable of resisting the effects of artillery fire, and, of course, if there are tools enough this may be dug at the same time as the trench.

It may sometimes be desirable to afford infantry greater protection from the effects of artillery fire, where the slope of the ground in front admits of it, by making the trench of the parapet only a few inches above the surface, and digging the trench proportionately deeper, the earth being spread out more in front; but it is very desirable not to place troops close in front of any obstruction to an enemy's shells, which should be allowed to pass harmlessly to the rear if possible, and therefore no earth should be thrown out of the trenches to the rear.

The author considers it much better to dig trenches fit for men to sit or stand in, than those requiring them to lie down.

In positions where the front of attack is narrow, or which are of vital consequence, or when no obstacles can be formed in front, as well as at salient angles, it is often desirable to make arrangements for 2 or 3 tiers of fire, and the Turks at Plevna made use of the counterscarps of their works for this purpose, forming them with a step for the defenders to stand on for firing.

If the slope of the lower part of a hill is steeper than the upper part of it, it is desirable to form a shooting trench on the brow of this steeper portion, so that the fire from it may thoroughly sweep the space below, and another shooting trench may be formed on the brow of the upper portion of the slope, in which case it is necessary to make the front trench so deep as to be useless to an enemy for firing from if the defenders have been driven out of it.

If parapets with bonnets are to be defended by two ranks the tallest men may fire *over* the latter, whilst the other half may fire through the loopholes between, so as to double the amount of fire from that part when it is most required.

To prevent the trenches becoming wet or muddy, from rain or springs, drains must be formed along the rear of the bottom of each trench, in general towards a flank, so as to carry the water off to the nearest hollow, and it is desirable to strengthen the steps and parapets with sods, bundles of rushes and brushwood, planks, logs, &c., as time permits. It will generally be better to cut down a hedge which is not in the best position for defenders to command the front rather than to attempt to render it shot proof by digging a ditch in front and throwing the earth against it, but this may sometimes be done with advantage, and especially where it is intended only to screen troops in reserve.

Of course care must be taken to prevent the works executed interfering with the movement of the defenders to *the front* where necessary, and therefore the Commanding Officer ought to act in concert with the Engineers at all times, whilst the latter must in every way encourage and assist them to *set to work soon* and to *continue* the works, even under fire, if evident advantages, as regards either cover for the troops, or additional facility for defence, can be gained, so as to give confidence to them and secure the most determined resistance with the least loss.

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*Note by the Translator.*—As there appears still to be an impression that it is desirable that each man should carry a pick or shovel, to enable him at all times to form cover for himself, it may be useful to observe that everything should tend to render the infantry soldier capable of marching, shooting and charging most perfectly, and that every addition to the weight which he must carry lessens his efficiency; yet that with breech-loading rifles it is most important that he should carry as much *ammunition* as possible; and when it is considered that tools would be the first things to be dropped in case of retreat, and that they can be carried in large quantities by a few mules led by men of the Engineer Troop to any point where they are required, it appears best *not to increase the load* carried by the infantry soldier, except occasionally by adding to his ammunition, the weight of which is likely rapidly to diminish in action. The rapidity of executing any work required, and the willingness to do this quickly, which are often of vital importance, will certainly be much increased by preventing the unneccessary fatigue caused by the men carrying tools. The main object should be to concentrate all the tools on the spot where they are needed, and, considering that only one Division, or a Brigade or two of an army usually require to be intrenched at the same time, the labour of carrying tools, and the cost of providing them, would be enormously and unneccessarily increased either by loading every soldier with a tool or adding "infantry carts" or wagons enough to carry one for every man.

Since the above was written General Skobeleff's report on his failure at Plevna has been printed, see page 102, of *Occasional Papers*, Vol. 2, and in it he says :—"Infantry soldiers after any brisk action return for the most part without tools. A soldier when he advances to the attack over difficult country relieves himself first of his entrenching tools, and so on." Surely this shews that the Engineer Officers should have charge of the tools, should not issue them to the troops till they are to be used, and must take care afterwards to have them collected.

As the opinions on this subject of *Officers of Infantry* are important, the following extracts from Major A. Griffiths's *English Army*, p. 215, which I did not see until long after writing the above, may be read with advantage.

After remarking that the entrenching tools carried in the regimental cart would never be at hand when required, he says, "that if a large number of men *carried* tools, and could dig holes at will, the consequences would be serious even with the finest infantry in the world, and they would cling to them with the affection which naturally invests the work of a man's own hands. * * * All that is needed is that there should be a certain proportion of tools at certain fixed points just when most urgently required. This will probably be most efficiently accomplished by placing the whole responsibility in the hands of that arm upon which the construction of works naturally devolves—the Royal Engineers. Fractions of this corps, with great power of mobility, should be attached to every Infantry Brigade, * * * and the infantry working under scientific supervision would execute far more than the desultory labour of double their number."

P.J.B.

# PAPER XIII.

# PROVISIONAL FORTIFICATION.

By Lieut. G. S. Clarke, R.E.

Recent experience and the present power of the infantry weapon will probably bring about changes of some importance in field fortification. In two directions, at least, modification may be expected. In the trace of works the present range and rapidity of fire will probably diminish the importance of flank defence. The basis of all trace has hitherto been the effort to cross the ground of attack with as many lines of fire as possible. In fact, it is in this direction that the greatest ingenuity on the part of military engineers has been displayed. The increased power of direct defence by securing the effect of many cross-fires with the immense advantage of concentrating the firing power in the hands of a few, whereby complete co-operation is assured, will, it can hardly be doubted, diminish the importance of trace. The Turks at Plevna seem to have fired with extreme wildness—in many cases simply laying the rifle on the parapet and pulling the trigger with merely the hands exposed—but the immense Russian loss, a loss which only an army of continental dimensions could afford, testifies to the destructive effect of even random shooting, provided that the *quantity* of shots is maintained. Again, the field redoubts of the future will have to be provided with a far larger amount of traverse and blindage cover than of old. The success of the Turkish defence depended very largely on the great security their works afforded to the defenders, security equally against the weather and the enemy's shell fire. The huge expense of the Russian bombardments might probably have been spared: they did not even produce the moral effect claimed for artillery fire. Poor in many respects as the Turkish works seem to have been, they were at least well traversed. Again, it is quite possible that obstacles in advance of the main ditch will increase in importance, and the ditch itself will be left unflanked

Some of the most striking lessons of the last war relate to what the Germans term "provisional" or "position fortification," giving it thus a specific name, and making it a special branch of study. On this subject an important lecture lately delivered before the Engineer Officers of the Berlin garrison, by Captain Von Wittenburg, has been reprinted in the *Archiv fur die Artillerie und Ingenieur Offiziere*. Confessing that as yet the probable modifications as well as the increased importance of this branch of military engineering have not been fully appreciated in Germany—a fact he attributes to the improbability of any immediate necessity for its application, the lecturer quotes the definition of provisional fortification in the pioneer handbook, and condemns it as inadequate. The latter runs somewhat as follows:—"Provisional or position fortification comes into play in the preparation for defence (Armirung) of a fortress, especially in the construction of detached forts and shelters for troops and stores. It is limited by the consideration that masonry must give place to wood and earthwork, and that the profile is slight." For this he would substitute:—"Provisional fortification embraces not only the problems relating to the building and construction of provisional forts and intermediate works, which arise in the preparation of a fortress for defence, but includes the strengthening of independent positions of which the events of a war have shown the importance. Such fortified positions may be strong independent points of support in rear of an army to secure its communications, or strong self-contained defensive positions in which an outmatched or defeated army seeks to protract a resistance no longer possible in the open field." The execution of the latter is obviously a very different matter from the mere preparation of a field of battle, but, on the other hand, fortification should, as a science, preserve an unbroken chain of sequence, and a lower form should on occasion be capable of development into a higher. Thus a well prepared field of battle should be convertible without organic change into a defensive position. Of such a development Plevna is a remarkable example. The lecturer states it as his opinion, that in Germany the time requisite for the formation of a Plevna would seldom occur, still cases are conceivable in which such strong defensive positions might play the part of a fortress. In England, on the other hand, the time and means for the formation of many Plevnas would always be granted, and for us, therefore, provisional fortification has a special interest.

The very important question as to whether in England provisional fortification, may not entirely supersede permanent works for all but coast defences, must be studied afresh with the light of the experiences of Plevna. Given two months, an ample staff of labourers, particularly carpenters, a sufficient supply of sawn timber, and it is probable that a defensive position of any assigned resisting power can be created. After a short preliminary consideration of the whole subject, Captain von Wittenburg proceeds to discuss the details of provisional forts, giving drawings of typical works, and laying down the following general conditions:—(*See* Plate.)

The profile should provide security against light siege artillery, the earth to be provided both from an exterior ditch and from an interior trench. The command of the crest on the front lines to be about 2·3*m*., in order to facilitate the construction of blindages, and also to cover the interior of the work more fully. The parapet to have a thickness of from 5*m*. to 6*m*. and the line of the crest to show no projections, which would only serve to give some clue to the general disposition of the work. Traverses at right angles to the parapet are, therefore, the same height as the crest of the latter. To this point considerable importance is attached. The crest of the flanks in rear of the extreme flank traverses declines to a command of only 1·8*m*. The drawing represents a typical fort for two companies of infantry. Two sections AB and AB*a* are proposed, the former shews a ditch 3*m*. deep, with a glacis sloping down to a second advanced ditch with obstacles. In AB*a* a ditch of ordinary form is dispensed with, and there is an excavation, in prolongation of the plane of the superior slope, terminating in a steep counterscarp, against which the abattis is fixed. The latter plan, though possessing advantages, necessitates a great horizontal movement of earth, and the employment of a large number of wheelbarrows or carts. The interior trench behind the front lines of the work is 3·5*m*. broad at bottom, and 1*m*. deep, falling to 1·5*m*. at the gorge, by which the drainage of the whole work into the exterior ditch is secured. The gorge is closed by a parapet 1·3*m*. high, and 3*m*. thick, with a tambour-like projection to flank the entrance. The gorge ditch is 2·5*m*. deep. The gorge is covered by two traverses containing blindages for officers, two sections of a company, and a cooking place. The 4-*m*. opening between these traverses is covered by a third traverse, with a blindage for the third section. The second company is lodged in the blindages of the faces and flanks. A defensive casemate in the gorge ditch shelters the guard. The entrance is closed by a barrier, and protected by a palisade in prolongation of the line of the ditch. The German plan of covering a drawing with + and − figures seems very rational, as shewing at a glance the height of any portion with respect to the natural ground.

The blindages are roofed with timbers of from 25 to 30*cm*. diameter, on which are laid planks carrying fascines, and 1·5*m*. of earth. A clear height of $2m$. is allowed, and $2m. sq.$ per man. The supporting timbers have $2m$. clear span. The drawings explain their arrangement fully. An alternative section, EF*a*, shews the front of the blindage supported on trestles, while the rear wall is revetted with two tiers of gabions in place of timber sheeting. Wherever possible, masonry set in a quick drying cement should be employed for revetments. Railway bars are of course recommended for roofing purposes when available. The construction of the blindages in other respects offers no special features, it is a matter which must in a great measure be left to the ingenuity of the engineer in dealing with the material at his disposal.

The excavation of the ditches of the front and flanks is first taken in hand, together with the preparation and collection of the timber for the blindages of the latter; those are commenced first, the construction of which is necessary so as not to delay the formation of the parapet. When the blindages are finished the gorge is closed, and the clearing of the ground in front and the preparation of obstacles begins. A work for two companies of infantry is taken as 6,000 tasks of 4 to 5 hours, this includes the labour of a company of pioneers. The formation of the revetment is carried on at the same time with the timber work, if no difficulties arise with the latter. The total time depends on the execution of the wood work. If wood and sufficient labour are available the principal blindages may be completed in four days. If sawn timber is at hand in sufficient quantity the work will of course be much accelerated. For placing obstacles and clearing the ground in front about two days are stated to be required, making a total of six days under favourable conditions, and say ten days under ordinary circumstances; night work does not seem to be taken into account.

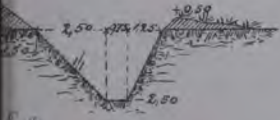
The lecturer discusses the question of ditch caponiers, and though he gives drawings of forts in which they are provided, he is inclined to decide against them on three grounds—their difficulty of execution, unless the time available is comparatively great, the inadequacy of the flanking power really afforded, and the liability to destruction by high angle fire.

G. S. C.

B


B a






F a


Section I K.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## PAPER XIV.

# INSTRUCTIONS FOR PONTOONING

## IN THE AUSTRIAN SERVICE.

*Communicated by the Secretary, R.E. Committee.*

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### Description of the Bridging Material.

The *trestle* is two-legged, the transom sliding up and down the legs, and being suspended from the head of them by chains.

The *transom* consists of a beam of 6 inches by $8\frac{1}{2}$ inches section, and 17 feet 2 inches long, rather broader at each end, where a slot is cut to allow the legs to be introduced, either singly in the case of short legs, or double when longer legs are used. There is a ring fixed on the transom near each slot, to which the suspending chains are fastened by a key attached to the beam by a small chain.

The *legs* are of four lengths, namely, 8 feet 3 inches, 12 feet 4 inches, 16 feet 6 inches, and 20 feet 8 inches; of which the shortest ones only are used single. The feet are shod with an iron shoe. When only one leg is used in each slot a piece of wood is put in to fill the place of the other leg, and is carried for this purpose.

*Shoes* of two sizes, according to the nature of the soil, are used to prevent the legs sinking in the ground, and are keyed on to the feet.

The *chains* have at one end a ring to which two links are fastened, which fit on to the head of each of the legs. The other end is put through the ring on the transom, and keyed.

A *lifting jack* is used in various ways with the trestles and waggons, and is carried with them.

A *shore transom* is used to receive the bridge superstructure whenever it rests on the ground, as at each end of the bridge.

Small and large pickets, iron-shod, are carried to secure the shore transom, and a small maul to drive them in with.

The *pontoon* is made by joining two or more parts together; these parts are of two forms one called the *fore part*, the other the *centre part*.

Each part is made of sheet-iron, strengthened by angle-iron ribs rivetted to it, and has an open flooring of planks connected by cross-pieces. The parts are joined by hooks attached to the sides by rings, each hook fitting into the ring belonging to the adjoining part. The centre part is nearly rectangular in section being slightly broader at the top. Its dimensions are 11 feet 4 inches by 6 feet 2 inches broad, and 2 feet 6 inches deep.

The forepart has the same section as the other, except near the front portion, where the bottom curves gradually upwards to meet the gunwale, thus forming a prow to the pontoon, and offering less resistance to its passage through the water. The front portion also is rather narrower than the midship breadth. The forepart is 14 feet long, and has the same section as the centre part.

The weight of the centre part is 876lbs., and of the end part 914lbs.

The displacement of each is about 11,040lbs. Besides the interlocking hooks, the parts are connected by bolts passing through holes close under the gunwale.

The superstructure of the bridge consists of *chesses* laid across *baulks*, and racked down with *half-chesses* used as ribands. The baulks rest on the *transom* in the case of trestles, but in the case of pontoons on *saddles*, which are exactly like the shore transom.

The *saddles* rests on *thwarts* laid across from gunwale to gunwale, except where two parts of the pontoon are joined, where a *block* of wood supports the saddle in a crutch on its upper surface, itself being kept in place by a pin projecting below fitted into the steering rowlock holes of one part of the pontoon. The *thwarts* are of two kinds, *cleated* and *common*. The former are like small baulks, with claws at each end to grip each gunwale. Their section is rather more than 6 inches by 4½ inches, their length 7 feet 1 inch. For short bays they may be used as baulks. The common thwart is 6 feet 2 inches long, and 6 inches deep like the other, but only 2½ inches broad, two are, therefore, used together, instead of one cleated baulk.

The *baulks* are 23 feet 2 inches long, and have a section of rather more than 6 inches by 4½ inches. Their bearing is nearly 22 feet. They are cleated at each end to fit the saddles. Each cleat consists of a block of wood, with a notch in it to fit the saddle, secured by two iron bands.

The *chesses* are 10 feet 8 inches long, $1\frac{1}{2}$ inches thick, and nearly 1 foot broad. They are a little narrower for a distance of 1 foot 6 inches from each end to allow of racking down. The *half-chesses* are exactly half a chess, and are used where there is not room for a whole one, and as *ribands* for racking down.

The stores carried in the pontoon are: *oars*, *boathook*, *anchors*, *rowlocks*, *cables*, *breastlines*, *cable-stick*, *bailer*, *roller wrench* for screwing the parts together, *painter* 18 feet long, *sounding line*, *racklashings* 12 feet long.

The *rowlocks* are iron crutches fitting into holes in the gunwale, both for rowing and steering with.

The *cablestick* is used to fasten the cable to the thwart. The *cable* is about 40 fathoms of 3-inch rope.

The *anchor* is 5 feet long, and weighs 125lbs.

The *boathook* is painted in foot lengths to assist sounding.

The *roller* is used to run on a tight cable for flying bridges.

The *waggons* are of four kinds.

*Baulk Waggons*; *Trestle Waggons*; *Store Waggons*; *Forge Waggons*. They are all constructed, with slight modifications in details, on the same plan.

Their centre of gravity when loaded is so low that they can lean over 30° without upsetting.

The track of the wheels is $45\frac{1}{2}$ inches.

The *Baulk Waggon* has the axles about 2 feet further apart, in order to carry the baulks. It seats three men, the Trestle Waggons six, the Store Waggons five.

The waggons are fitted with a brake working on both hind wheels, as well as a drag-shoe, with an ice-shoe with a sharp edge fitting over it for use in winter.

The team for each waggon is four horses in pole draught.

The *Baulk Waggon* carries:—1 fore-part of pontoon; 5 baulks; 23 chesses; 7 half chesses; 2 trestle legs; 1 chain; 4 oars; 2 rowlocks; 1 thwart; 1 anchor; 1 painter.

The *Trestle Waggon* carries:—1 centre part of pontoon; 3 saddles; 2 transoms; 10 trestle legs; small stores required for trestles; 2 thwarts; 2 blocks to support saddle, and some small stores.

The *Store Waggon* carries a large chest full of tools required for the pontoon train, and small stores, such as lashings, rowlocks, sounding line, &c.

The *Forge Waggon* contains:—a forge with bellows fitted on the waggon; anvil; farriers' tools; smiths' tools, &c.

Both the above carry a centre part of pontoon in addition. Details and drawings of all the tools used are given in the regulations, but are omitted here.

The details of packing the waggons, and of their construction are also omitted.

# PAPER XV.

## TRIALS OF

# SHELL-PROOF AND BOMB-PROOF COVER,

*Compiled from Official Sources*

BY JOS. CEIPEK, CAPTAIN OF THE ENGINEER STAFF.

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*Abstracted from "Mittheilungen über Gegenstände des Artillerie-und Genie-wesens," by Captain J. W. SAVAGE, R.E.*

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IN the report upon the experiments at Olmütz, in 1875, with 21 c.m. elongated shells against bomb-proof structures it was remarked, with regard to temporary roof constructions, that it would not always be possible to reckon on the degree of strength which had been attained on that occasion chiefly by means of iron rails. It appeared, therefore, desirable to make further experiments to test how far a double row of heavy wooden baulks with a thicker covering of earth would afford the necessary protection.

The experiments in 1876 aimed at giving a decisive answer to this question; they were held, as well as those in 1877 and 1878, on the *Steinfelde*, near Wr. Neustadt.

The experiments in 1876 differed from those of former years, in, that the bomb-proof roofs under trial were not laid horizontally, but at such a slope that an equivalent effect could be obtained at a short range, by taking care that the conditions of velocity and angle of impact remained the same as they would be for any given longer range. In this way the cost of the practice was reduced to a minimum.

Splinter-proofs for use in the field were tried in the same way with the 9 c.m. 1875, and 12 c.m. 1861, B.L. field guns, and the short 15 c.m. B.L. gun.

For the trial of the bomb-proofs the 17 c.m., and 21 c.m B.L. mortars were detailed in the programme. The results of the trials compared very favourably with those of other years. Of course the thoroughness of the experiments could be gainsaid in one or two small points, such as the difference of effect produced by the blow of the projectile on a bomb-proof roof tilted up as described, as compared with one in its proper position, in which latter case some lateral swaying motion would be set up. The difference, however, is not sufficient to impair the practical value of the trials as a comparison of earlier and later results will show.

On the whole, however, the results of the shooting, together with those obtained from the explosion of shells placed on the roofing baulks, did not furnish a thoroughly conclusive answer to the questions under solution.

In the first trials with 21 c.m. shells placed by hand, they were always immediately over the baulks; but the effect must be different when, as is usually the case with a fired shell, there is a layer of earth or shingle (*Schotter*) between it and the timbers at the time of explosion. It was, therefore, absolutely necessary to test this point, and with this object experiments were made in 1877. At the same time the strength of the side walls of blindages, &c., against 12 c.m., 15 c.m., and 21 c.m. shells was tried.

The principal object of these fresh trials was, by a gradual diminution of the thickness of the earth over the timbers, to arrive at the limits which gave the best security to the interior of the blindage.

In the experiments of 1877, undertaken for purely artillery reasons, the targets for the 17 c.m. and 21 c.m. B.L. mortars consisted of horizontal blindages of wood and earth. The number of hits obtained was too small to prove anything respecting bomb-proof cover. The practice of the following year against the targets already mentioned produced finally the desired results.

The following are extracted from the official reports:—

### Experiments of 1876.

1. *A field blindage.*—Timber and earth. The roof inclined at 20° to the horizon in order to give similar results at a short range as would be given by the curved fire of the 9 c.m. field gun at 1,875 metres (2,500 paces), or by the direct fire of the 12 c.m. B.L. gun at 4,000 metres, with 17° elevation.

Roofing baulks 15 c.m. square, touching, in one layer; distance between supporting capsills (running longitudinally) 3 metres;

thickness of earth one metre, to be finally reduced according to programme to 0·6 metre, and 0·45 metre (*Fig.* 1).

2. *A Bomb-proof Casemate* (*provisorischer Decke*).—Roof inclined, part 34° (*Fig.* 2), and part 61° (*Fig.* 3); corresponding respectively to the fall of the 15 c.m. gun at 4,000 metres, with 30° elevation, and the 17 c.m. and 11 c.m. B.L. mortar at 3,400 metres, with 60° elevation. Path of projectile at short experimental range nearly horizontal.

The roof consisted of one layer of baulks in one place; of two layers (laid crosswise) in another, and, in a third, the second layer of baulks was replaced by a double layer of rails, the lower of which was spiked to the baulks, while the upper rested in the interstices of the lower. The remaining spaces were filled with cement concrete.

The revetments of the sides were of 15 c.m. baulks, the framed supporting timbers of the whole about 30 c.m. square. The earth covering was on the average 2 metres thick.

The table at the end of this paper gives particulars of charges, &c.

*Results of the Practice.*—The field guns against the field blindage gave well-defined results, admitting of the following deductions being made, viz.:—A single layer of 15 c.m. square baulks, with 0·45 metre of stone rubbish* (*erdigen scholter*), or 0·6 metre of garden earth on top, is proof against the curved fire of the 9 c.m. field gun. The same timber roof covered with 1 metre of rubbish, or 1·33 metres of garden earth, is proof against the 12 c.m. B.L. gun.

Bearing in mind the application of this construction in the field, as in field casemates, blockhouses, and the like, it may here be mentioned that the width of 3 metres between the supports of the roof timbers admits of a guard-bed 1·9 metres broad with a passage of 1·1 metres, pre-supposing of course that the struts of the outer row of uprights are inclined outwards, those of the inner row inwards.

It is further to be remarked that the above deductions only hold good as long as the conditions of charge and terminal angle do not materially differ from those in the experiment.

A roof composed of a double layer of 15 × 15 c.m. timbers, with a covering of 1·5 metres of garden earth, will resist the curved fire of the short 15 c.m. B.L. gun with common shell (charge 0·91 k.g.)

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* The 9 c.m. shells produced craters in the stone rubbish about 0·2 to 0·3 metre deep, and 1·8 to 2 metres diameter.

The 12 c.m. shells made craters about 0·35 to 0·4 metre deep, and 1·6 to 2 metres diameter.

falling at an angle of 23°. With a long shell ($2\frac{1}{2}$ cal.) and double the bursting charge, the same roof, but with 1 metre of stone rubbish over it, will not give sufficient security.

These experiments fix the minimum dimensions for wooden constructions under the above circumstances.

In order to give the desired strength in the case last mentioned, the earth covering must be increased. It may be assumed, however, that with an additional support to the roofing baulks placed at the foot of the guard-bed (*i.e.*, 1·9 metres from the back of the blindage), this construction, with 1 metre of stone rubbish over it, would give ample security even against repeated blows of the long shell fired from the short 15 c.m. B.L. gun with elevations under 30°.

A blind shell from the 17 c.m. B.L. mortar penetrated 1·5 m. into the stone rubbish in the direction of the trajectory, and was found 0·5 m. above the roof timbers. Blind shells curved upwards during penetration.

The 21 c.m. B.L. mortar produced no effect against the section which had a covering of rails.

## Experiments with Buried Shells.

These were made especially to test the strength of the walls of blindages against the explosion of 15 c.m. and 21 c.m. shells at high angles, as the Olmütz experiments gave no reliable data on this head.

The revetment consisted of a single wall of 15 × 15 c.m. timbers. Against this was placed a $2\frac{1}{2}$ calibre 15 c.m. shell with ordinary bursting charge of 1·82 k.g. of R.L.G. powder, buried in the earth backing and exploded with a Bickford fuze. Five timbers were cut through by the explosion, making a hole 0·5 to 1 metre long; large and small splinters of wood were thrown to distances of 50 paces, and a large splinter of the shell was driven into the opposite wall of boards with such force that it could not be removed by the hand.

This showed that the necessary degree of security could only be directly obtained by strengthening the side revetment.

Next, in order to test the roof in a similar manner a 21 c.m. shell, with 3·92 k.g. bursting charge, was placed on the roof timbers of a *provisional* blindage (*Fig.* 2), with its axis perpendicular to the length of the timbers, and lying flat in the middle of the space between two of the supports of the latter. There was 0·5 metre of earth on the top. Bickford fuze was used to explode the charge.

The explosion destroyed the two baulks immediately under the shell for nearly the entire length between the supports; a third baulk, viz., that next to the head of the shell, was split in the direction of its length as far as the front support; the capsill of the rear support was badly shattered through half its thickness.

A second 21 c.m. shell was exploded in a similar manner over a double layer of 30 × 30 c.m. baulks (*Fig.* 2*a*), but it was placed rather nearer to the rear support. The baulk under the head of the shell in the upper layer was shattered for a length of 1·5 metres, and that next to it under the body of the shell was bruised right across. In the lower layer the baulk immediately under the shell was broken, and those on each side of it as well as the two supporting capsills were badly split.

These experiments were considered conclusive as to timber roofs.

## Experiments of 1877.

The practice of the year 1876 had given especially remarkable results in two directions.

It was proved that field blindages and those of stronger construction used in *provisional* works possessed a very considerable power of resistance against fired shells. From the experiments with buried shells it appeared, on the other hand, that shells exploded against the walls and on the top of the roofing baulks had a most destructive effect. This would naturally lead to a strengthening of these walls and roofs. That of the walls cannot be evaded; to thicken the roofs would be to act in accordance with the principle laid down and borne out by the previous experiments on the Steinfeld and Olmütz, viz.: that the roof itself should be proof against shells bursting on it, and that the earth covering should be able to resist the penetration of shells fired at high angles. But considering how favourable the results of actual practice were to the target, much opposition arose on economical grounds to the strengthening of the roofs, and those favourable results were undoubtedly to be principally ascribed to the circumstance that the shells did not succeed in penetrating as far as the actual roof before bursting, but were separated from it by more or less earth or stone rubbish, which very considerably diminished the effect of the explosion.

If, therefore, roof timbers of minimum dimensions were to be used (and this seemed desirable for other reasons besides that of economy), it was necessary to determine what thickness of in-the revetment. These trials were considered conclusive as to revetments of planks.

The next trials were with a wall of 15 × 15 c.m. timbers laid horizontally (*Fig.* 11.)

A 12 c.m. shell was first tried, placed as in the figure. The wall remained unimpaired by the explosion: no damage could be seen.

A 15 c.m. shell, placed as shown also in *Fig.* 11, broke one of the uprights at the height of the sixth timber, pushed out the timber over this unbroken, and disturbed a few others.

The struts were strengthened and the damage repaired for a repetition of the experiment with a 15 c.m. shell placed at the level of the 4th baulk from the bottom, the other conditions being as before. The explosion showed a rupture of the 3rd baulk and of the strut of the upright, and displaced the baulks over the broken one.

The Committee expressed their opinion that revetments of boards should not be used for the sides of blindages in provisional works, as they required too much earth to render them secure.

Also that against 21 c.m. shells, at high angles, side walls of 30 × 30 c.m. baulks are necessary.

## Experiments with Curved Fire against Horizontal Roofs, November 20 to 23.

The target consisted of two blindages constructed of framed timbers, sunk nearly 3 m. below ground level, and covered—one with stone rubbish, the other with garden earth. Each blindage was 9·5 metres square in plan. (*Fig.* 12.) The pieces used were the 17 c.m. and 21 c.m. R.B.L. mortars.

The former, at 2,400 m. range, with a charge of 2·14 k.g., gave an angle of fall of 70°, and a terminal velocity of 190 m.

The latter, at 3,400 m. range, with a charge of 4·76 k.g., gave an angle of fall of 60°, and the same terminal velocity.

The shells contained the ordinary bursting charges of 2·8 k.g., and 3·92 k.g., respectively. They had also copper wire gas checks, and delayed action percussion fuzes, the trial of the former of which constituted the principal object of the experiments.

The practice began with the 21 c.m. mortar, from which a good hit was obtained on the shingle roof on the first day. A crater was made of 3·2 m. mean radius and 1·13 m. deep, without injuring the wooden construction. Splinters of the shell were found 1·3 m. below the upper surface.

On the second day a shell hit the garden earth roof, and made a crater 2·1 m. in diameter and 0·6 m. deep without injuring the roof; a splinter was found 1·3 m., and the head of the shell 1·5. m., below the surface.

On the third day both roofs were well hit.

In the stone rubbish covering the effect was hardly visible; most of the splinters were found about 0·8 m. down. In the garden earth covering a crater 2·2 m. diameter and 6 m. deep was formed. No damage was done in either case to the woodwork.

The 21 c.m. ammunition being expended, this piece now ceased firing.

All the live shells which exploded on the stony surface of the practice ground made craters of 1·63 m. mean diameter, and 0·77 m. mean depth. Of those which were fired blind some remained where they fell, 0·5 m. below the surface; others cut furrows 2 m. long and 0·4 m. deep in the surface of the ground, and finally lay 4 to 8 m. beyond the point of impact. In the experiments with the 17 c.m. mortar the stone rubbish roof was hit once, making a crater 2·3 m. diameter and 0·8 m. deep. The blind shells that fell on the ground were generally found 0·3 m. deep, with their heads towards the firing point. The live shells made craters of about 1·2 m. diameter, and 0·57 m. deep, *i.e.*, down to the hard substratum.

The committee were of opinion that the shells had not come entirely to rest before explosion, although the fuzes appeared to have acted perfectly, and burnt 0·4 second after striking.

### Experiments on Sloping Roofs.

The target sloped 34°, and was constructed as shown in *Fig.* 13. The effect was calculated to correspond with that of the 15 c.m. B.L. mortar at 4,000 metres, with 30° elevation.

The piece was placed 100 m. from the target; the elevation due to this range was $42\frac{1}{2}$ min., and the reduced charge was 0·98 k.g. (1·48 being the full.) The shell, $2\frac{1}{2}$ calibres long, had the ordinary bursting charge of 1·82 k.g. Two blind shells fired consecutively hit the target in the middle at a height of 1·6 m. above the ground, and were found in a nearly horizontal position, with the axis parallel to the direction of the timbers of the upper row of baulks close to the edge of the rear slope, and 0·53 m. distant from the woodwork. No damage was apparent in the interior of the blindage.

The three following live shells penetrated to nearly the same position as the blind ones, exploded and showed very insignificant results, as no damage was done to the woodwork, and the earth filled up the holes made by the explosion.

After this the thickness of earth was reduced to 1·6 m. Still the effect of two shots was insignificant.

A further reduction of the earth to 1·3 m. showed no decided result, and even a final thickness of 1 m. was still sufficient to protect the roof completely from any appreciable damage. When the roof was laid bare, a few splinters were found on it, but the woodwork had suffered no damage.

The experiments were now concluded, as it was ruled that blindages could not well have less than 1 m. of earth over them.

### Conclusions.

As the experiments with curved fire had shown the thickness of earth used to be excessive, it was desirable to make further experiments to arrive at a minimum.

The results obtained with the short 15 c.m. B.L. gun proved that a roof composed of a double cross layer of 15 by 15 c.m. timbers, with 1 m. of garden earth over them gave full security against the 15 c.m. shell at 4,000 metres with 30° elevation.

### Experiments of the Year 1878.

The experiments with 21 c.m. shells fired at high angles were continued in order to try and achieve conclusive results.

The target was the same as before (*Fig.* 12), but the earth covering was reduced.

The range was 3,400 m.; the bursting charge 3·75 k.g.; deferred action percussion fuzes were used. The live shells weighed 86·5 k.g.

14 shots were fired with blind, and 85 with live shells, and the latter gave three good hits on the stone rubbish roof, and eight on the garden earth.

The greater proportion of the splinters of the shells penetrated to 1·5 m. below the surface of the stone rubbish, and in the garden earth 1·8 m. to 2 m.

On the whole the penetration somewhat exceeded that of former years, speaking well for the improved action of the longer delayed fuzes. The results of the practice on the wooden construction were considerable, the lower layer of baulks, as before, suffering most in splits and breakages, and proving that the thickness of 1·9 m. of stone rubbish, and of 2·4 m. of garden earth, under the conditions of the practice, must be regarded as rather under the minimum.

It is to be remarked that throughout the whole of the preceding experiments the wood used was of good quality.

J.W.S.

| Description of Gun. | Projectile. | Conditions. Actually employed. Distance, Metres. | Charge, k.g. | Elevation. | Final Velocity. | Terminal Angle. | To correspond with. Distance. | Charge. | Elevation. | Final Velocity. | Terminal Angle. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Practice against Field Blindages. | | | | | | | | | | |
| 9 c.m. R.B.L. Field Gun, M. 1875. | Common Shell with 2 k.g. charge. | 375 | 0·42 | 2°·47′ | 180·4 | 3° | 1875 | 0·42(?) | 18°·52′ | 146·4 | 22°·46′ | Against the Shingle *(Schotter)* roof. |
| 12 c.m. do. M. 1861. | Do. with 52 k.g. | 500 | 0·6 | 3°·10′ | 207·3 | 3° | 4000 | 1·1 | 17° | 205·6 | 22°·27′ | |
| Short 15 c.m. R.B.L. Gun. | 2½ cal. Shell with 1·82 k.g. charge. | 500 | 1·10 | 3°·31′ | 192·9 | 3°·42′ | 3200 | 1·5 | 20°·17′ | 192·8 | 23°·23′ | Do. Do. |
| | Common Shell with ·91 k.g. charge. | | 1·105 | 3°·3¾′ | 192 | 3°·30′ | | | | | | Against the garden earth roof. |
| | | Practice against Provisional *(Provisorische)* Blindages. | | | | | | | | | | |
| Short 15 c.m. R.B.L. Gun. | 2½ cal. Shell with 1·82 k.g. charge. | 100 | 0·98 | 0°.42½′ | 186 | about 0°·50′ | 4000 | 1·48 | 30° | 186 | 34°·30′ | |
| 17 c.m. R.B.L. Mortar. | Common Shell 3·13 k.g. charge. | 100 | 1·82 | 0°·40′ | 190 | about 0°·50′ | 3475 | 2·28 | 60° | 190 | 65°·10′ | |
| 21 c.m. R.B.L. Mortar. | Common Shell 3·92 k.g. charge. | 100 | 3·69 | 0°·40′ | 190 | about 0°·50′ | 3400 | 4·76 | 60° | 190 | 63°·34′ | |

# PAPER XVI.

## DESCRIPTION OF THE METHOD ADOPTED FOR

# HOISTING THE GIRDERS OF THE QUOINA BRIDGE,

## SATTARA DISTRICT, BOMBAY PRESIDENCY,

BY CAPTAIN E. C. HART, R.E.

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IT is often as useful to know how not to do a thing, as how to do it. The following few lines bring this fact forcibly to our notice, and it is hoped may prove of interest to some of our readers. Should diagrams or descriptions herein given not be as clear as could be wished, we crave the indulgence of the reader on the plea, that many sketches and notes have been lost since 1872, in which year the operations about to be described took place. The problem to be solved early in the above-mentioned year was the best method of placing "in situ" the iron superstructure of the Quoina bridge.

*Description of Locality, &c.*—It may be as well here to give some idea of the locality, as well as of the nature of the superstructure provided for erection. Briefly then, the main road from Poona to Belgaum, and thence *viâ* Dharwar to Madras, a line of communication of vast importance crosses the Quoina river about half way between the towns of Sattara and Kolapoor, or 100 miles from Poona, one mile above its junction with the Krishna river. The bed of the Quoina is soft sand or mud and, while the river was still unbridged, presented very great difficulties to traffic, especially during the monsoon, or wet weather, when heavy rain in the hills would bring down a flood of 30 or 40 feet in depth in the course of a few hours. The bridge, as designed, consisted of two stone arches of 50 feet span, and four spans of 108 feet each. For the latter, the necessary iron work was sent out from England. The foundations for the piers of the stone arches and the abutments appear to have been got in without difficulty, rock being found within a reasonable distance from the surface, but a whole volume would be required to describe the difficulties encountered whilst getting in those for the remaining three piers, which had, owing to a fault in the rocky bed, to be sunk to a very considerable depth. This was, however, eventually successfully and ably carried out, in 1871, by Capt. (now Major) A. R. Seton, R.E., and the piers raised to the requisite height of about 70 feet above the river bed.

The iron superstructure sent out from England is known as Brotherhood's lattice girder, and is partially represented in *Plates* Nos. I. and II.; it was supposed to be specially adapted for colonial use, owing to the fact that the largest pieces were not of either extreme weight or bulk, thus rendering transport easy; the whole structure was fastened together by bolts instead of rivets, thus securing a minimum of skilled labour. There is no doubt the iron work itself can be put together very expeditiously, for it was found that from 40 to 50 men could put together a span of 100 feet in from $1\frac{1}{2}$ to 2 days, supposing that the scaffolding, &c., was all ready before they commenced work.

*Description of Iron Superstructure.*—The following is the description of the Quoina bridge superstructure, and the tests applied :—

Each span, 116 feet over all, 108 feet clear span.
Clear width of roadway between uprights, 22 feet.
Weight of heaviest piece in the bridge (one cross girder), 6 cwts.
Length of „ „ 22 feet.
Total weight of one span without buckled plate flooring, 53 tons.
Weight of buckled plate for one span ... ... $11\frac{1}{2}$ „

Total weight one span ... ... ... ... $64\frac{1}{2}$ tons.

*Tests.*—One span was tested thus :—The platform was first loaded uniformly with a dead load of 75 tons, to represent the road material. A live load on 11 broad gauge trucks (weight included) of 108 tons, was then run forwards and backwards over the span, giving a deflection on the centre of $\frac{7}{8}$ths of an inch. On the removal of the live load the permanent set was found to be $\frac{1}{16}$th of an inch. The camber given was $4\frac{1}{2}$ inches.

*Cost.*—The contract price for four spans complete, including all charges of painting, packing, &c., and delivery alongside, Port of London, was £4,713 16s. 0d.

*Contractor's Method of Erection.*—The following is the method recommended by the contractors for erecting the iron work. (See *Plate* III.) :—

"On the floor of the scaffolding place blocks of wood (as shown in *Plate* III.), at a distance of 13 feet apart, directly under the centre lines of the bottom chords; on these blocks place two wedges, as shown, these are to give the proper camber to the bottom chords, viz., $4\frac{1}{2}$ inches in the whole length of chord. The bed plates being fastened to the pier at their proper distance apart, and the rollers placed on them; lay the roller plates and end bars of angle iron fastened together upon them, and across the wedges, lay the angle iron bars with the plates between them from block to block, and, fasten them together temporarily with drifts.

"The bottom chord thus laid, erect the stanchions in order, and place the packing pieces under them between the plates, and fasten with drifts; place the tie-rods in order, and then insert the lattice bars through the stanchion and the ends between the bottom chord plates, and fasten with drifts; this done, place the cross girders on the angle-iron brackets riveted to stanchions, and fasten them together; place the T iron strut under the cross girder, and fasten to same and bottom chord. Lay the top chord angle irons in order, and connect them with the tops of stanchions, with the ends of lattice bars between them; bolt the lattice bars and stanchions to chord, and lay the top blocks on the angle irons, and bolt up—remove drifts one by one, inserting bolts in their places, and tighten up. Lay the buckle plate flooring on the top of cross girders, and of plates, and fasten to cross girders and stanchions, put the T iron, fasten the same, place the longitudinal angle iron along the outside braces over this angle iron, and secure it to stanchions and cross girder.

"See that all bolt nuts are tight, and the wedges and scaffolding can be removed."

*Reasons for adopting Method of Hoisting.*—The above plan was successfully carried out for the northen span, where the height above the river bed was not excessive, but for the remaining three it was deemed advisable to adopt the method of hoisting, as, owing to the great height (over 70 feet) a timber scaffolding would have been extremely costly; moreover, as the monsoon was near at hand it would have been necessary to erect a separate scaffold for each span simultaneously, for which purpose neither materials nor labour were forthcoming. In point of fact, the adoption of this method of fixing the girders by hoising, eventuated in a great saving of cash to government, and enabled the bridge to be completed before the commencement of the approaching monsoon.

The plan adopted was as follows :—

*Method of Hoisting.*—The two main girders of each span were put up side by side in the bed of the river, close to the down stream cut-waters of the piers on which they were eventually to rest, the up-stream girder in every case being next the piers.

*Description of Gantries.*—Two gantries (as shown in *Plate* IV.) were constructed, the scantlings being calculated for the strains the several parts had to bear; thus, AA were cross sills, into which were halved longitudinal sills BB, fixed to which, by wrought iron knees and bolts, were the uprights CC, which were braced in both directions by the struts DD and EE. On the top of the uprights, and attached thereto by wrought iron knees and bolts, were the longitudinal bearers FF, which it will be noticed projected considerably beyond the down stream end of the piers, to allow of the girders swinging clear of the cut-waters, which had considerable batter. On the top of the bearers were spiked iron rails, and two small trollies were constructed to run thereon, one for each gantry; these trollies carried treble sheaf blocks, a double sheaf block being attached at either end of the compression boom of the girder about to be raised. A half-inch chain was rove through each set of blocks, taken to a pulley at the up-stream extremity of the gantry, thence through a single block (attached to the base of the pier by means of a chain passed round it), and finally, to a crab winch some 80 feet up-stream. On the down-stream side, also, in the prolongation of the axis of the gantries were crab winches, the ropes therefrom being attached to the trollies, so as to regulate their traversing motion.

*Minutiæ to be attended to.*—There were some minutiæ which it is well to mention; for trivial though they may appear, failure of attention thereto would have caused serious delay and inconvenience.

1st. The crab winches had to be placed in the proper position, and very firmly secured to piles driven into the river bed ; otherwise a fouling of the tackle would have ensued.

2nd. All bolt holes in the woodwork of the gantries had to be very carefully and truly bored to obviate any delay in withdrawing and again inserting the bolts.

3rd. The screw bolts, at any rate those in the longitudinal sill, had to be of such length that when the nut was removed and their heads rested on the top of the pier, their ends should not project above the surface of the sills.

4th. The gantries themselves had to be placed with their longitudinal axis considerably to one side of the axis of the piers, so that the points of suspension of the girders might be in the axis of the gantries.

5th. It was found a saving of time, and in every way more satisfactory, to construct the gantries complete on *terra firma*, rather than to handle heavy pieces of timber on the top of a pier 8 feet in width and 70 feet high, so advantage was taken of the shade afforded by the stone arches already constructed—for it may here be casually mentioned that a tropical sun in the months of April and May is not a power to be despised, iron tools exposed to its rays could not be handled until plunged into cold water. One native, in the airy undress of the East, occasioned much amusement by inadvertently sitting down on a crowbar; he did not remain in that posture long, and his howl of anguish elicited peals of laughter from the bystanders. The gantries, therefore, were completed on *terra firma*, the adjacent parts being marked with corresponding numbers, then taken to pieces, and erected in their proper positions on two adjacent piers.

*First Failure and Cause thereof.*—All was now believed to be ready for hoisting; the up-stream winches were manned, and the first girder rose to a height of 12 feet, by which time it ceased to graze the cut-waters; hardly was this the case, when the top boom was seen to buckle horizontally sideways, the girder turned over on its side and collapsed; in fact the top boom, a long pillar in compression, was unable to stand the pressure, and failed as any other pillar in like circumstances would have done. An exactly similar failure occurred, it is believed, when hoisting one of the girders of the Crumlin viaduct. It is easy "to be wise afterwards." Fortunately, in the present instance no great damage was done, as the failure occurred whilst the girder was near the ground; the girder was taken to pieces, the bent plates, &c., straightened, and the whole put together again in about a couple of days.

*Prevention of Buckling.*—There could be no doubt as to the reason of the failure; the question was how to prevent the buckling, and to do this it was determined to truss the top boom horizontally on both sides; this was done as shown in *Plate* V. The struts were made of pieces of railway iron laid on side and bolted together; between these were pieces of teak abutting firmly against the boom on either side. The central strut was made to project about $\frac{1}{40}$ the span, or say 3 feet on either side, the minor struts were placed in the centres of the half spans, and were made $\frac{1}{40}$ of the half span, or about $1\frac{1}{2}$ feet. The tie rods of the trusses were made of the $\frac{3}{4}$-inch tie bars of the bridge itself, as being the most convenient material at hand. Theoretically speaking, it is believed that a wire would have been an efficient tie, but, practically, much latitude had to be allowed for the following reasons:—

1st. It is impossible to align such a structure in a *mathematically* straight line to start with.

2nd. The boom contained numerous joints, the slightest play in which would vitiate all calculations.

3rd. Jars, while the process of hoisting was in progress, were inevitable.

4th. The pressure exerted by gusts of wind had to be allowed for.

Three-quarter inch wrought iron bars were therefore used for the purpose, and it is believed were ample.

The ends of the railway rails projected above 1 inch beyond those of the teak pieces, to preclude all danger of the ties slipping out of position.

*Second Failure and Cause thereof*—All was now again ready for hoisting, and the winches were accordingly manned, and the girder raised to a height of about 40 feet. Suddenly one of the ties of the improvised trusses snapped near the central strut, and the girder collapsed exactly as previously described, with this exception, that being so much higher above ground, it was more seriously injured, and in its fall it dragged with it, and destroyed both the gantries. In the face of such a result it may be asked, how can the opinion just previously given, viz: that a $\frac{3}{4}$-inch bar was sufficient, be supported? The reason is this—on examination of the broken tie, fracture was found to have occured at a point where one of the eyes of the tie rods had been villainously ill welded to the bar by the makers; the tie having been painted before leaving England, the defect was not noticeable; it is a wonder how the weld stood as long as it actually did. It is needless here to expatiate on the feelings of those principally concerned in the success of the enterprise, suffice it to say, that it was decided to make one last push to complete at least one span, and such was the energy displayed, that not only one, but all three spans were completed, and the bridge open for traffic before the monsoon fairly set it. Timber and iron were telegraphed for from Bombay, and the interval before their arrival was fully occupied in testing and examining all chains, bolts, &c., and selecting from the ruin what little material was of use.

On the arrival of the necessary stores, the gantries and trusses were constructed exactly as before, with the single exception of the ties, which were made of 1-inch bar, each component bar being heated and "jumped up" at the ends, and holes then punched therein, so as to avoid all welds. Whilst this was in progress, the broken girder was taken to pieces, repaired, and rebuilt, and the hoisting carried out exactly as previously described, but fortunately without any further failure or hitch of any description whatever.

All that now remains to be explained is the method of getting each girder into its proper position, which was as follows:—

*Traversing the girders.*—As a girder rose, and, owing to the batter, cleared itself of the pier starlings, the guys attached to the down-stream crab winches were eased off, thus allowing the trollies to move inch by inch up stream, hence the leverage on the cantilevers of the gantries continually decreased until, when the top boom touched the inclined cantilever struts, the leverage was only about 2 feet, the hoisting was then stopped until the struts were removed, and then again continued till the bottom boom could just clear the top of the longitudinal sills of the gantries, when the down-stream guys were eased off, and the girder allowed to traverse inwards until it touched the first of the uprights C C, when it was allowed to rest on the longitudinal sills. A hydraulic 6-ton jack was now placed on the top boom, between the girder and the bearer, and the weight of the latter being thereby removed from the upright, and its bolts withdrawn, it was slipped away, while a temporary support was inserted on the outside of the girder; the jack was then removed, the girder slightly raised, and allowed to traverse until well past the position of the upright, then again allowed to rest on the sill, and the bearer, raised by means of the jack and the upright, re-bolted in its original position. In a similar way each upright was passed, and the girder traversed the whole length of the pier, until it came over its proper position, when it was lowered into its place. The down-stream girder was next handled in the same way; it should, however, have been previously mentioned that the sills were so constructed that a portion, somewhat wider than the width of the bottom booms, could be unbolted and removed, so as to allow the girder to pass through and rest on its rollers. The cross girders were now fixed, and there was no longer any danger of failure.

One gantry was then taken to pieces, and rebuilt on another pier, the other was simply "shunted" across the top of its pier into its proper position for use on the next span, when the process was repeated.

The weight of each main girder was about 19 tons, exclusive of adjuncts; it is probable that the actual weight did not fall short of 20 tons, or 10 tons on each gantry.

It may be thought from the description that the process was a tedious one, but in reality, it was wonderful how quickly it was performed when once the men understood what was expected of them, due regard having been paid to the minutiæ before noted.

E.C.H.

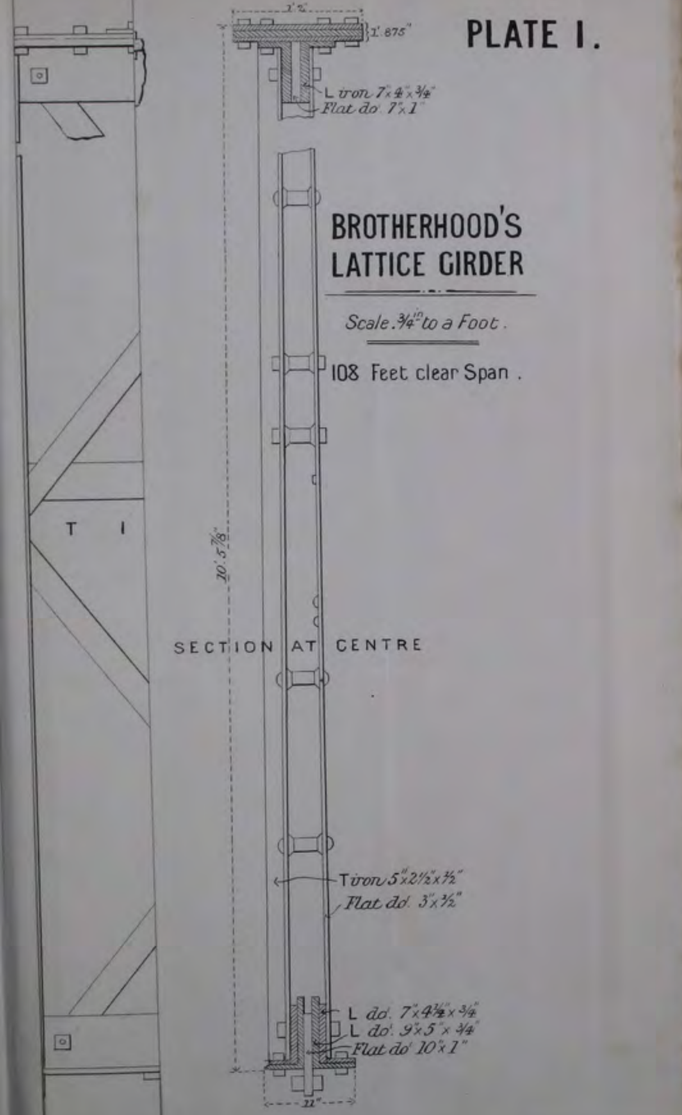
PLATE I.
BROTHERHOOD'S
LATTICE GIRDER
Scale. 3/4" to a Foot.
108 Feet clear Span.
SECTION AT CENTRE
1' 2"
1' .875"
L iron 7" x 4" x 3/4"
Flat do. 7" x 1"
10' 5 7/8"
T iron 5" x 2 1/2" x 1/2"
Flat do. 3" x 1/2"
L do. 7" x 4 3/4" x 3/4"
L do. 9" x 5" x 3/4"
Flat do. 10" x 1"
11"
T
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PAPER XVII.

# ON COAST FORTIFICATION

AND THE

# NAVAL ATTACK OF FORTRESSES.

By Major Arthur Parnell, Royal Engineers.

## (1.) On Naval Fortress Warfare.

It is probable that in a time of national war the duties of our navy will lie mainly in the attack or blockade of an enemy's coast fortresses.

This branch of naval warfare would therefore appear to be particularly deserving of study on the part of naval officers and naval constructors.

The maritime nations of the world have by no means neglected the formation of fortified ports, and it is only in the defence of these strongholds that our enemies can hope for successes over our fleets.

It would therefore not be wise for us to reckon on foreign powers omitting to arm their sea fortresses with their heaviest and most effective ordnance.

In order to know how to take fortresses it is necessary, in the first place, to know how to make them ; in fact, a knowledge of the art of fortification is a pre-requisite.

A fortress cannot be attacked by land without the attacking engineer being a thorough master of the art of defence, and the same rule holds good in the attack of fortresses by sea.

In like manner as it is said, *through obedience learn to command*, so it may be said, *through defence learn to attack*.

Fortification is now regularly taught at the Royal Naval College at Greenwich, but there are probably still many naval officers who have never given close attention to the subject, and these officers would naturally be liable to fail in comprehending the true value of fortification.

Our naval history will show that in actions against forts we have gained fewer laurels than in purely sea combats.

Of course, there is much in the very nature of things that would tend to account for this fact.

Before the era of ironclad ships, wooden ones, however well armed and manned, could hardly effect much injury on well designed and *properly armed* stone forts.

To the accuracy of this statement, Sebastopol and Cronstadt, in the Russian War of 1854-5, have given the clearest testimony, the one directly, the other indirectly, whilst *vice versa* it may be remarked that one of our greatest achievements in war occurred in the successful resistance of stone walls to wooden ships, viz., at the memorable action of the 13th September, 1782, between the sea fortifications of Gibraltar and the combined floating batteries of France and Spain.

The most recent operations on any significant scale in the warfare of which we are now treating, appear to be the naval portion of the American Civil War of 1861-5, and the naval attack on Sebastopol on the 17th October, 1854.

In the American War we know that in several instances ships did successfully engage forts, and did also pass channels commanded by their guns.

These actions were mostly, however, fought in rivers, and independently of that, were hardly of a magnitude sufficient to guide us to correct ideas on the subject of the naval attack of a great fortified arsenal.

The nearest approach to the latter operation seems to have been the Federal naval attack on Charleston, and this was totally unsuccessful.

Generally speaking, the conditions of the actions in which the Federal ships were victorious, appear to have been somewhat as follows:—on the one hand numerous vessels of good construction, well armed and well manned, and on the other hand—

1st. Forts, either antiquated or improvised.

2nd. Weak guns, mostly 32-prs., or other and smaller smooth bores, the rifled guns few and bad, and all indifferently equipped and mounted.

3rd. Inferior powder.

4th. Few shells, and such as there were, bad.

5th. Ill-trained gunners.

If this is an approximately correct idea of the conditions of these engagements, it will be admitted that there is not much ground for wonder at the Federal successes.

It is submitted, however, that the attack by the allied fleets on the 17th October, 1854, on the sea forts of the great arsenal and dockyard of Sebastopol, will constitute a far more reliable and useful lesson for our guidance as to the relative powers of ships and forts before ironclads and rifled guns were used.

The facts are narrated in detail by Kinglake in his history.

The sizes and powers of the guns used on each side were probably so nearly equal that we may fairly take the *numbers* of guns, whenever mentioned, as giving a true idea of the artillery power employed.

The proportions of shot to shell used on either side were, also, probably about the same.

Here are the facts. The allied English and French squadrons with a united *broadside* of 1,100 guns, engaged the more prominent of the Sebastopol sea batteries for three or four hours in the afternoon of the day in question, at ranges varying from 600 to 3,000 yards, the opposing batteries being armed with 152 guns, of which 105 were in the open, and 47 in casemates. Of the open guns, 100 were behind stone parapets, and 5 (in the Telegraph Battery) behind earthen ones, whilst 90 were at a level of 30 to 40 feet above the sea, 5 (in the Telegraph Battery) at a level of 100 feet, and 5 (in the Wasp Battery) at a level of 130 feet above the sea.

The batteries were named and armed, as follows:—

*Against the French Attack.*

| | |
|---|---|
| Quarantine Fort (all open) ... ... ... | 33 guns. |
| Fort Alexander (some open, some casemated)... | 17 ,, |
| Fort Constantine ,, ,, ... | 23 ,, |
| Total ... ... ... | 73 ,, |

*Against the English Attack.*

| | | |
|---|---|---|
| Quarantine Fort and Fort Alexander | some open, some casemated ... ... | 36 guns. |
| Fort Constantine | " " ... | 20 " |
| Wasp Battery | (all open) ... ... ... | 5 " |
| Telegraph Battery | " ... ... ... | 5 " |
| Other Batteries (some open, some casemated) .. | | 13 " |
| Total ... ... ... | | 79 " |

The brunt of the French cannonade was directed at 1,600 yards range against the open Quarantine Fort, whilst the French ships were respectively 2,000 and 3,000 yards distant from Fort Alexander and Fort Constantine.

The English fleet was divided into two squadrons, one of which operated at long range (about 1,600 yards) with the French fleet, and the other, the "Inshore" squadron, stood in at a range of 600 to 800 yards, and directed its fire mainly against Fort Constantine.

The French, with a broadside of 706 guns, engaged the 73 guns that replied to them with the following results :—

*On the Russian Side.*

Quarantine Fort—3 guns dismounted; 30 men killed or wounded.
Fort Alexander—3 guns dismounted; 20 men killed or wounded.
Total—6 guns dismounted; 50 men killed or wounded.

*On the French Side.*

200 men killed or wounded.

The English "Inshore" squadron did most of the work on the English side, and probably nearly all the injury received by the Russians, apart from what has been credited to the French, was due to the fire of this squadron.

It consisted of the following ships :—

| | | |
|---|---|---|
| "Agamemnon," | 45 | guns on broadside. |
| "Sanspareil," | 33 | " " |
| "London," | 45 | " " |
| "Albion," | 45 | " " |
| "Arethusa," | 25 | " " |
| Total, | 193 | " " |

The "Rodney" (45 on broadside) joined afterwards.

The squadron took up a position against Fort Constantine in a dead angle, whence they raked its open upper battery, whilst only two of its guns could reply.

They had altogether directly opposed to them,

| | | |
|---|---|---|
| Fort Constantine, | 2 | guns. |
| Wasp Battery, | 5 | „ |
| Telegraph Battery, | 5 | „ |
| Total, | 12 | „ |

The main results of the "Inshore" squadron's attack were as follows :—

*On the Russian Side.*

The upper tier of 27 open guns at Fort Constantine was silenced (the gunners being driven below by the stone splinters), and 108 men (including losses from the long range English squadron) were killed or wounded, of whom 22 cases occurred at the Wasp Battery but none at the Telegraph Battery.

*On the English Side.*

*a.* The "Inshore" squadron was beaten off, mainly by the Wasp and Telegraph Batteries.

*b.* Two ships, the "Albion," 90, and the "Arethusa," 50, were put *hors de combat*, and obliged to proceed to Constantinople to refit.

*c.* 320 men were killed or wounded (including the long range squadron).

To sum up—the attack of the allied fleets, despite the great preponderance of artillery on their side, was altogether unsuccessful. The total loss of the allies was two ships, carrying 140 guns, disabled, and 520 men killed or wounded, whilst the Russians had 33 guns dismounted or silenced, and 158 men killed or wounded.

Thus we see that a fleet thoroughly well equipped, comprising the best ships, officers, seamen, and guns in the world, choosing its own time, positions, and ranges, attacks a line of fortifications, of whose defects in design it takes full advantage, and over whose artillery it has a preponderance in power in the proportion of 7 to 1, and after three hours fighting it is beaten off with a loss in men and guns four times greater than it has inflicted on the forts, although two-thirds of the forts' guns were fought in the open, and two-thirds of the ships' guns were fought under cover.

In these days the disparity between forts and ships is unquestionably even greater than it was then, and the following are the principal reasons for this :—

1st. The comparatively greater liability of modern heavily weighted ironclad ships to be sunk.

2nd. Each individual line-of-battle ship is of much more relative value in a squadron, and its individual loss or disablement is so much the more a general disaster.

3rd. The vital advantage over the seamen in ships that the gunners in forts always had, in fighting their guns from a rigid platform instead of from one in perpetual motion, and hence in sending their projectiles with far greater precision, is now intensified, owing, partly, to the greater degree of accuracy of which guns, on account of their rifling, are now susceptible, and partly to the immensely increased weight and destructive power of their projectiles.

All these considerations seem to show that the art of attacking naval fortresses is one that is of the utmost importance to our navy, and that the study of it is of a cogency at least as great as is the study of naval tactics for engagements between squadrons.

It is impossible, however, that the matter can be fully appreciated, unless the true place of fortification in naval warfare is first thoroughly recognised.

A few remarks will therefore be made on this point before proceeding further.

A naval system may be said to consist of three elements, viz., men, ships, and ports.

Now it is of the third element that we are at present treating.

The term *Ports* is here used in its widest sense, and is intended to include not only the factories and arsenals of a navy, such as Portsmouth, Toulon, and Wilhelmshaven, but also important dockyard harbours such as Malta and Bermuda, coaling stations such as Gibraltar and Aden, and even mere roadsteads, such as the Downs.

We all acknowledge the importance of our various naval ports and coaling stations, and the necessity for insuring them against the unlikely but possible event of our experiencing a naval disaster at sea, or such a continuous series of smaller misfortunes as might amount to such, but we do not all understand how, practically, they would be worth nothing if fortification did not lend its aid to keep them for us.

This is the part that fortification plays in naval warfare. It secures our ports.

Let us examine this more closely. Supposing our ports were un-fortified, a considerable proportion of our ships, however powerful our navy might be, would of necessity be employed solely in protecting them, and this, in order not only to guarantee for the remainder—the fighting ships—the certainty of finding safe places whereat to refit, revictual, and repair from time to time, but even to allow of our having any ships at all.

Now, it is a matter of simple investigation of figures to prove that such a system as this would be so wasteful as to be unendurable, and it is a matter of rudimentary study of the art of war to convince oneself that it would be ineffective.

Fortification is merely a form of economy. It enables us to secure our ports, money for money, in the most efficient manner, and it allows the whole of our ships to be free to be used in their most advantageous form, *i.e.*, in a form involving motion; in other words, in offensive fighting.

By the term *Fortification* is meant not only the works of water, mud, sand, earth, wood, concrete, brick, stone, rock, or iron, as the case may be, built or formed, to keep out the enemy and his shells, but also the guns arming these works, or otherwise defensively placed in position, the obstructions barring the channels, the mines sunk beneath the waters, the torpedo vessels and armed boats, essential for night and thick weather operations, and the garrisons necessary to animate all these material defences.

Fortification is as much economy in respect of rendering a port safe as a fence erected by a farmer round his field is economy in the way of making the field secure. The farmer could keep off trespassers and intruders, whether man or beast, by constantly employing a staff of watchmen; but as the use of a fence is equally effective, and much cheaper, he adopts that method.

It need hardly be observed that fortification, like everything else, is liable to be misused, but naturally, the more it is understood the more it is likely to be properly applied.

The maintenance of our naval supremacy renders it necessary for us to treat our ships as of more importance than our ports, but with every other maritime nation it may probably be said that their ports are of a value to them equal to their navies.

Taking all things into account, the attack of their ports would seem to be the primary object for the attention of our navy, and the defence of them the main subject of anxiety for their governments.

With the knowledge that the ports our ships had left behind them, and that those on which they relied for coaling and refitting, were well fortified, our squadrons could freely sweep the seas of their enemy's navy and commerce, and could put forth their full power in attempting to reduce his fortresses.

The policy of our establishing ships for the mere purpose of coast defence seems undoubtedly erroneous. Mastless turret ships, such as the "Thunderer" and "Glatton," and others of great resisting strength, but not so well adapted for ocean cruising, should rather be styled coast attack ships, and should be reserved for the express purpose of attacking fortifications, for which they appear to be, in most respects, well suited.

The idea of employing our navy during war mainly in securing our ports, and in defending the communications between them (as has apparently been lately suggested), seems like putting the cart before the horse.

The ports should surely be self-dependent, and be used for the service of the ships. The contrary course appears to be a suicidal one, and, in fact, to constitute an abdication of the throne of the seas.

It is clear that the communications between our ports cannot be interrupted if the enemy has no ships to interrupt them with. But it may safely be asserted that our navy and steam mercantile marine would be so developed in a time of serious hostility as to afford a reasonable hope that anything that should show itself afloat belonging to the enemy would soon be effaced.

We ought to hunt their ships from port to port, and never to rest satisfied until they were either driven behind their fortifications, added to our own navy, or sunk at the bottom of the sea.

The word *Defence* ought to be unknown in our navy, except (as aforesaid) in connection with the study of the attack of fortresses.

(2) ON FORTS AND BATTERIES.

The sea defences of a fortress may be divided into three classes, viz.,

*a.* Guns and works, *i.e.*, batteries.

*b.* Booms and mines, *i.e.*, obstructions.

*c.* Torpedo vessels and armed launches.

The end of the batteries is to hit the ships, and to sink them as rapidly as possible, and any protection given to the guns is merely a means to that end.

A gun mounted in a good position, and well served, might very possibly, without having any parapet or defence in front of it at all, sustain an engagement with a ship, and even sink it.

It is considered that under nearly all circumstances the barbette system of mounting guns should be employed, because, 1st, the guns are in their most effective state for offence; 2nd, the works are in their least expensive form; 3rd, the known inaccuracy of the fire of ships' guns is fully taken advantage of.

The chief feature of the barbette system is unrestricted training, and guns for coast defence ought seldom to be placed in positions where a training of not less than 120° would not be of use to them.

For commanding channels and rivers guns are not so effectively placed when at bends, or other points suitable for obtaining a flanking fire, as when lining the shores of reaches.

In the former cases their fire bears on ships chiefly whilst they are end-on; but in the latter it bears, or tends to bear, on their broadsides.

In fact, as compared to front fire, flanking fire is of little value in coast defence, and, moreover, it involves crowding the guns at particular points, and hence, casemating them, and protecting them with iron.

In a line of barbette batteries each gun is free, owing to the comparatively unconfined training it possesses, to support its neighbours (independently of any great scattering of the guns), and this appears to be the great merit of the system: for, although each of the guns is relatively more exposed than if it was mounted behind an iron shield, yet the combined fire of them all on the ships is far more deadly, since more guns can at any moment converge their fire on the ships, and the combined protection obtained in this way is proportionally greater.

In fact, each gun makes up, and in most cases more than makes up, for its relative loss of protection by means of its extra powers of offence; for it is clear that all offence in warfare is a species of defence.

Guns are now made of such a size and power that, apart from the question of desirability, the mere fact of expense will probably prevent their being mounted in the future in coast batteries, in iron turrets, or even behind iron shields or fronts, of adequate strength.

But it is considered that independently of the cost, the use of iron armour in coast fortification is not, and never will be needed, and mainly on account of the want of precision of naval gunnery.

The open sea experiments by the "Monarch," "Captain," and "Hercules," off Vigo, in 1870; the "Hotspur's" experiment in Portland Harbour against the "Glatton," in 1872, and the combat between the "Shah" and "Huascar," in 1877, are notable confirmations of the inaccuracy of ships' fire.

In regard to the first mentioned experiments, Captain Colomb, R.N., in his lecture at the Royal United Service Institution on the 3rd April, 1871, arrived practically at the following conclusion with reference to the "Monarch" and her 25-ton guns, viz.: That with each of these guns she would, at a range of 1000 yards, only hit a target 300 feet long by 15 feet high, once in 10 rounds.

The "Hotspur," on a sea like glass, firing with her 25-ton guns at the "Glatton," at 200 yards range, experienced a vertical deviation in her fire of about three feet, as the mean of her three rounds.

And in the engagement between the "Shah" and "Amethyst" on the one side, and the "Huascar" on the other, the two English ships together appear to have fired 431 rounds at the "Huascar," and to have hulled her only nine times, whilst the "Huascar" did not once strike either of her antagonist's hulls.

The barbette system of mounting need by no means necessitate the exposure of the gun detachment.

The gunners can be well protected as follows:—

1. With guns of 7 tons and 12 tons, by using Moncrieff's carriage.
2. With guns of 25 tons (and doubtless other weights), by the "Temèraire's" hydraulic disappearing method.
3. With guns of all weights, by depressing the muzzle by ordinary means after the gun has recoiled from firing, and then introducing the ammunition and rammer from sunken shell-proof recesses or casemates, formed underneath, or in rear of the parapet.

In the last method, which seems by far the most simple and economical, the gun itself is, to some extent, exposed whilst loading, but this is a minor evil (which is referred to farther on with reference to the question of the concealment of guns), and especially so with heavy guns, as compared with the exposure of the gunners. The rammer, or rammers (for there might be several radiating from the gun's pivot) might be worked by hydraulic agency with guns weighing 38 tons and upwards.

If this cover-loading system can be thoroughly developed, as there is good reason for believing it can be, the two first mentioned systems of protection would hardly ever be needed, and indeed it might be advisable to give even guns that could otherwise be mounted in the ordinary simple barbette the economical protection thus afforded.

Command above a certain height, however, generally allows of heavy guns being mounted with acknowledged benefit in barbette pure and simple, *i.e.*, without protection to the detachment whilst loading.

This height may probably be taken at 80 feet above H.W.M. if the gun is in the front line and close to the edge of the cliff or height, and, perhaps, at 50 feet above H.W.M. if it is well retired from the line of coast.

A barbette battery of whatever nature should always have shell-proof shelter for the gunners adjacent to the guns.

As regards the turret system of mounting guns, this method has undoubted advantages when used on board ship, where it gives great facility for disposing efficiently the weights of guns of exceptional size, and where—since a ship is liable at sea to fire all round the compass—its great training power is of much value.

On shore, however, the case is different. The occasions on which guns when mounted on shore would be really required to fire round a whole circle can hardly be imagined. Supposing them to be mounted on islets in a channel, the very fact of their firing to their rear would show that the enemy's ships had passed them, and would prove so far the uselessness of mounting guns at all in such positions.

The turret plan seems, in fact, for shore purposes, a somewhat barbarous one. On account of the enormous expense of efficient turrets, the system cannot reasonably be adopted without coupling two guns together in one turret. And this necessitates that whenever you wish to train *one* gun on an object, you must lug round with this gun not only the great mass of iron forming the turret, but also the other gun.

Moreover, without either of the guns in the turret being actually disabled, the machinery of the turret itself may, from various causes, become ineffective, at all events, for a few minutes, and thus both guns would be placed *hors de combat* for that time.

As compared with a gun behind an iron shield, a barbette gun has this advantage, that in the case of the shield there is a region of danger to the defender from the more or less vertical faces of iron or stone that must occur all round the port of his shield, whereas above and on each side of a barbette gun there is nothing but air to stop an attacker's shells, whilst below it the gentle upper slope of the parapet or glacis, especially if of concrete, is almost sure to deflect an impinging shell harmlessly.

But perhaps the weakest point in all iron structures for defence is the little scope they afford for mounting in or behind them ordnance of a nature heavier than that for which they were originally designed. This is an especially serious objection in these days, when the weight and size of guns is increasing at such a tremendous rate. A difficulty of this sort is reduced almost to *nil*, at all events to a *minimum*, in barbette batteries.

Owing to the absence of small ports for firing through, a barbette gun possesses greater facilities for aiming at ships and for following them up.

If disabled it can be replaced with far greater ease than if it was mounted in a turret.

Probably, also, great loss of nerve or stupefaction to the senses will be experienced by gunners shut up in a turret, should a heavy shell once strike it fairly, owing to the fearful concussion and vibration occasioned thereby.

To sum up, the main advantages of the barbette system over that of iron shields, fronts, and turrets, appear to be as follows:—

1. Much less expensive.
2. Free from liability to disablement by means of its own protective appliances.
3. Easier for aiming.
4. Greater facilities for mounting guns heavier than those for which originally designed; and, in addition, as regards turrets,
5. Less difficulty in replacing.
6. Nerves and senses not so liable to be shattered or scattered.

It is submitted that iron coast defences should be treated as among the things of the past, and that the barbette is the coast battery of the future, and this even for guns not of the heaviest weight.

The barbette system is probably as old as artillery, and it is clearly the natural method of mounting a coast gun.

If a position, elevated some 100 to 150 feet above H.W.M., and distant not less than 400 to 600 yards from the five fathom line, can be given to a barbette gun, whilst its rear is free from high rock, nothing would seem to be more advantageous for the defensive artillery.

With these levels and distances the gun's fire would be in its most effective form, and the ship's return fire would be comparatively inefficacious.

As regards "protected" barbette guns of all natures, the undoubted loss of rapidity of fire occasioned by the particular method used for protecting the detachment can be compensated for by increasing either the weights or the numbers, which, if the guns could have been mounted in pure barbette, would have been deemed sufficient for them.

The barbette system requires a greater space between the guns than when they are placed behind ports and embrasures. But, in considering the whole scheme for the defence of a port, sufficient ground could probably, in most cases, be obtained without any serious difficulty for mounting all the guns efficiently in barbette, whilst, in specially confined sites, and in places where space was an urgent consideration, due credit should be given to the greater training the fewer guns would be capable of, and any additional power needed could be given by increasing their weight.

The barbette gun is in its most beneficial, or rather *maleficial*, form when at a certain elevation above the sea. In cases of batteries needed to protect channels having low banks, the disadvantage of the low levels must be made up for by increasing either the number or the weight of the guns; but if the gunners are duly protected there is probably no necessity for casemating the guns.

In advocating the barbette plan of mounting it is not intended to recommend any unusual dispersion or scattering of the guns. An engineer would provide such a dispersion or concentration of his guns as the circumstances of the site might call for, and no two sites are ever quite alike.

Of course it is understood that theoretically a greater efficiency of fire is obtainable when the guns and batteries are dispersed than when they are massed; but practically it is not always so, and there are many points to be considered on the subject.

The material of which to construct the parapets of barbette batteries will of course depend on the site. You cannot conveniently build earthworks on rocky plateaus, nor heavy masonry works on mud banks.

Probably, whenever the site will admit of the necessary foundations, nothing will be more advantageous for a parapet than Portland cement concrete. If you can mask its exterior faces with earth so much the better.

Cement concrete work is comparatively cheap, and as efficient for the purpose as granite, whilst it has less liability to give forth bad splinters. It takes up far less room (strength for strength) than earth, and it is by no means difficult to repair.

As regards the employment of casemates for coast guns, it is submitted that if good front cover is given to the gunners whilst serving the guns, and provided the battery is placed, as it always should be, so that it cannot be raked, the necessity for employing casemated batteries is to a great extent done away with.

Casemated batteries of the ordinary kind have these disadvantages :—

1. They are expensive.
2. They require iron shields at their openings if the guns are used for front fire.
3. They retain smoke more than do open batteries.
4. They will not, as a rule, accommodate guns heavier than those for which they were originally designed.

It has already been suggested that the *parapets* of batteries should be recessed or casemated, in fact built hollow, and that the loading should be effected by gunners stationed in these hollows, or by machine-worked rammers placed therein. The casemate system is thus practically applied to the battery, though the gun itself is uncovered.

Concrete casemates over the guns would, however, doubtless be useful in exceptional positions, such as the flanks of a line wall or escarp, where the guns were mainly intended to act against boats, where great training would not be needed for them, and where they would not be much exposed to front fire; but thick rope mantlets would suffice for the protection of the openings. Splinters and bullets would be kept out by these mantlets, and the chances of shells striking them might safely be risked.

In channels or roadsteads, where shoals, or islets rising slightly above the sea level, should afford opportunities of erecting on them casemated batteries, or towers, with two or three tiers of guns, necessarily somewhat crowded, and involving a copious use of iron, and where guns could not be conveniently mounted in barbette, at proper intervals, it is suggested that it would perhaps be better, in some cases, to mount no guns at all on these places, but, in lieu thereof, to utilize them so far as practicable in the formation of booms and obstructions, and to give the defences of the channel the necessary strength by increasing :—

1. The number and weight of the guns in the nearest shore batteries.
2. The number and power of the booms and obstructions, and
3. The force of torpedo vessels and armed launches.

On the subject of command, it may safely be asserted that it constitutes, next to rigidity of platform, the great advantage that land batteries are capable of possessing over ships.

Too much attention can hardly be paid to placing guns in positions, wherever it is practicable, whence they can have a decided command over the ships, and yet where their fire does not necessarily become "plunging."

It is submitted that low positions should never voluntarily be given to guns, and that batteries *à fleur d'eau* are among the most inefficient that can be devised.

There is only one species of coast defence battery less efficient than a battery *à fleur d'eau*, and that is a floating battery. In batteries of this kind the *acme* of inefficiency is reached. They involve a *maximum* of expense with a *minimum* of usefulness. In employing them you deliberately throw away all the natural advantages belonging to shore batteries, and you put yourself on a level—both figuratively and literally—with your adversary. You pay heavily for so doing, and you gain no single benefit in return, for mobility is quite an unnecessary element in coast batteries.

It has been said that floating batteries might command any dead water there might be in the port; but it is contended that ports have no right to contain dead water.

It may be thought that low positions are good for batteries so far as they tend to conceal them; it is maintained, however, that concealment is quite a secondary point with a defender. What he wishes to do is to hit his enemy—not to conceal himself. Now he can hit his enemy—*i.e.*, a ship—much more dangerously if he is on a level somewhat above the ship's deck, especially if at close or moderate range, and the ship can, in return, under these circumstances, do him less injury by its fire.

A ship's fire appears, as a rule, so wanting in precision, that considerations of concealment, either as regards guns or works should but little influence an engineer, more especially since the most suitable points for giving coast batteries all the offensive powers they are capable of, are usually prominent, and well marked from the sea.

It is believed that some naval officers hold the opinion that, when they cannot easily discern a coast battery, it should therefore be deemed an unusually effective one, and *vice versâ*, that, when batteries are situated on bold commanding eminences, and are easily visible, they need not be thought much of.

Now it is from these latter batteries that ships have most to fear. It may be depended upon that, where batteries are thus placed, they have been put there by the engineer solely because he thereby obtained greater accommodation for injuring his enemy. The battery doubtless presents itself to the ship as a fine target, but seeing a target is not hitting it.

On the same principle no great expense or complication should be entertained with a view of enabling barbette guns to disappear behind their parapets. The gun would seldom be struck, and if it was, it could probably stand with impunity, especially if of large size, many hard knocks striking its curved surfaces, and certainly from splinters; and it would hardly have to fear for any of its parts except the muzzle, and this would be covered, in all systems of protected barbette, whilst loading.

Moncrieff's excellent method of mounting, in the cases where it is applicable, gives cover, to a great extent, by means of this eclipsing principle, to both men and guns. The system appears, however, more advantageous for inland defences than for coast batteries, even supposing that it is practically successful with guns exceeding 12 tons in weight.

The main argument in favour of the employment of Moncrieff's carriages for guns in coast defence, when the system was first brought out, was the necessity that was *otherwise* supposed to exist for covering the guns with iron.

### (3). On Obstructions.

In considering the relative importance of the various branches of coast fortification, there is good ground for arriving at the conclusion that they stand in the following order :—

1st.—Booms and passive obstructions.
2nd.—Guns.
3rd.—Torpedo vessels.
4th.—Armed launches.
5th.—Works.
6th.—Mines, or active obstructions.

Theoretically speaking, the booms across a channel take the place of the escarp of a land fortress. If impervious they would constitute the main defence of the channel. But there are undoubtedly difficulties connected with the use of booms as against modern ironclad rams, and there seems to be a necessity for practical experiment as to the best form of boom for channels under various conditions of site. The *desiderata* appear to be :—

(*a*) A *maximum* of strength, elasticity, and buoyancy.

(*b*) Great facility for effecting repairs.

(*c*) A *minimum* of obstruction to friendly navigation.

Submarine mines form active obstructions to a channel across which they are sunk. They do not, however, form material obstacles, and it is probable that their value is chiefly of a moral nature.

The weak point in the best system of submarine mines is their necessary dependence on electricity. Those that are not thus dependent, *i.e.*, mechanical mines, are hardly worth mentioning, and are sources of danger to their employers rather than to those they are employed against.

If we think of other applications of electricity, either peaceful or warlike, we shall find that we have constant experience of their practical success. Take for instance the electric telegraph, the electric light, and electro-plating—we have, as regards each of them, daily evidence of their efficiency.

But in the case of electro-submarine mining—so far from our having continual proof of the effectiveness of the complicated electrical, mechanical, and explosive arrangements connected with it, we have, up to this day, hardly any proof at all; and from the very nature of the art, we are never likely to be *assured* of its certainty. It must always be in a stage resting on inductions from partial and piecemeal experiments.

A great naval war would probably teach us nothing on the question except the most practical methods by which these mines could be frustrated and prevented from carrying out the ends for which they were intended.

No ironclad ship of any navy is likely ever to venture over waters where there is the smallest chance of a mine lying sunken, without these waters having first been well searched, swept, and cleared by means of the countermines, or the other and simpler appliances which our own (and doubtless all other) naval officers know how to manage.

It may safely be asserted that, in the American civil war, submarine mines owed whatever success they had mainly to their novelty.

The very refinement and delicacy of the art of submarine mining militates against its chances of usefulness. The idea is one more fitted for the laboratory of a philosopher than for the rough and ready practice of naval warfare.

It has already been suggested that the value of these mines would be mostly of a moral nature, and this is one way of implying that, against daring sailors, their obstructive effect would be very slight.

It would seem prudent to treat submarine mines as a means of defence entirely subsidiary to booms and passive obstructions, and possessing a value proportional to the simplicity of its arrangements.

The "electro-contact" method, for instance, would probably be more useful under most circumstances than any other. In this we dispense with most of the electrical tests, the results of which are sometimes more a puzzle than a guide.

As regards the "electro-observation" method, it has been aptly remarked that "ignition at the right moment depends on most care-"ful observation, on the most accurate co-operation of a great number "of people, on the proper action of complicated apparatus, and on the "effective maintenance of the observing stations during the enemy's "fire."

It may also be added, that in thick weather and dark nights observation is of course at an end.

Doubtless, circuit closers, cables, batteries, earths, shutter apparatus, fuzes, and mines *ought* all to act aright and in unison when we want to use them; but *will* they do so? If, indeed, it ever comes to that stage—if, in fact, the mines are not previously placed *hors de combat* by some night diving, or other simple operation, involving nothing but pluck on the part of the enemy.

A disadvantage by no means to be overlooked is also the possibility, owing to misunderstanding, want of nerve, or other faults or accidents on the part of the operators, of one's own ships being sunk by the mines in lieu of those of the enemy. Great power for evil to their own side is placed in the hands of individual men, especially in the cases of great naval ports. None but officers could well be entrusted with this responsibility. In fact, looking at the question generally from this point of view, a sufficient staff of trustworthy operators could hardly be provided if the system was extensively adopted by a great maritime power having many ports and harbours to guard.

Comparing sea with land mines, the latter, though of a less subtle nature, would appear to afford, relatively, greater obstacles to an enemy's advance on a land fortress (under the recognized modes of land mining warfare) than would the former to a hostile fleet.

With all this, sea mines will doubtless, in many cases, be aids of some value to passive obstructions if used to a moderate extent, and in their simplest form.

### (4.) On Torpedo Vessels and Armed Launches.

The guns in shore batteries are all-powerful by clear daylight, and, perhaps, in moonlight nights; but in thick weather and dark nights they would be of less value.

It is suggested that torpedo vessels are at these times the proper supplements to guns in respect of their offensive power, whilst armed launches should replace them in their defensive aspect, *i.e.*, in guarding booms, mines, and other obstructions, and in preventing landings from boats.

There is no doubt, that in the new torpedo vessels now being constructed, for apparently every power in Europe, a great advantage is given to the defenders of sea fortresses.

There is something very practical in a swift Thorneycroft launch. These, and other torpedo vessels, are peculiarly suited to nations of a maritime temperament; whereas, submarine mines seem adapted to populations less accustomed to the sea, whose naval operations would, therefore, be cast in a less enterprising mould.

A naval fortress should certainly have a number of these torpedo vessels among its defences, with (if possible) naval officers to command them, for, in spite of the coasting nature of their action, they necessitate a *maximum* of seamanship, discipline, and daring.

A boom, a battery of two 64-pounders, and a torpedo launch would form an efficient and economical defence for a small commercial harbour, and the mere knowledge of the existence of such a defence would be the means of protecting the port from insult by isolated cruisers.

Armed steam launches would be most valuable adjuncts to the defence of a sea fortress, especially (as already said) at night. This would be the time when, besides the guns being less powerful, the defender would be repairing his booms, or laying, examining, or replacing mines (if he had any) from his mine prahms, and escorts would be requisite for both operations. These launches would also be very useful in patrolling.

### (5.) On Coast Defence Generally.

There are two ways of fortifying a port to seaward, viz. :—

1. Each battery or fort may be an independent enclosed work, and the intervening coast may be unoccupied.

2. The whole of the accessible coast line of the port may be defended by a line wall or escarp, behind which the guns can be placed at the best sites.

The first case is more adapted to shores of some extent and containing but few landing places.

The latter case is suitable to compact sites, and such as offer a more or less continuous line of coast available for landing at, and where the line of defence is close to the naval establishments or objects more especially needing to be guarded.

A few remarks may be made regarding the part that it is considered gunboats (armed with light or heavy guns) should take in coast defence. It is submitted that there is no field for the employment of these boats in the defence of great naval or commercial ports, and that in these cases they would be merely in the way.

But for the protection of long stretches of accessible coast, lying between considerable ports and harbours, it is thought that manned either by Coast Guard, Naval Reserves, or Naval Volunteer Artillery, and acting in co-operation with the land forces guarding these coasts, they would be very useful.

As regards the arrangement of the guns in a coast fortress, the heavier ones should certainly be on the lower levels, supposing the site offers a choice of levels, for, as already atated, low elevation is disadvantageous, and the more powerful the gun is, the more capable it is of fighting at a disadvantage.

Medium guns, *i.e.*, those of less weight than 7 tons, would be valuable in retired elevated positions, or in casemated flanks.

They are of value against:—

*a.* All parts of unarmoured ships.

*b.* The decks, rigging, and unprotected parts of ironclads, and

*c.* Boats.

In the American civil war they were found useful when associated with heavy guns, as their fire tended to distract the attention of the attacker.

They would be mounted either in pure barbette, and be given the utmost training obtainable, or, if only needed for flanking fire against boats, in casemates with rope mantlets, as already suggested.

During an engagement between the heavy guns with which they were associated, and ships, they need only be fought at convenient opportunities, and their action would then be of a somewhat desultory nature. Their effect on ironclads might, perhaps, be compared to that of hornets or wasps, on human beings.

They should have shell-proof shelter close at hand for their gunners.

The nature of the armament of a fortress, and the proportional numbers of the different guns composing it, would vary with the relative importance and the circumstances of the port, and with the naval strength of its most likely attackers.

The great benefit obtained by having the bulk of the ordnance of a naval fortress superior in weight to that usually carried by the average sea-going ironclad ships of the day should be fully taken advantage of.

Guns of any weight can always be mounted on shore at a reasonable expense, but it is not so afloat.

Herein lies one of the great inherent advantages that guns ashore possess over those afloat. In the one case you have only to mount your gun; in the other you have, in addition, to float it, and to move it.

In coast fortresses which do not afford sites for throwing a plunging fire, probably a proportion of rifled howitzers for curved fire would be useful.

The engineer would utilize high ground for forming thereon secure look-out stations and signalling posts. From these the phases of the action and the effect of the shells could be seen with distinctness, and with freedom from the smoke and excitement of the batteries. Orders can be telegraphed from these stations to the commanders of the batteries, and probably, also, the different ranges of the ships can be communicated.

Electric means would also be used for concentrating the fire of the batteries in salvos, whenever necessary.

Electric light would doubtless be employed in order to conduct the defence during night time to the best advantage.

Several officers have in recent discussions at the Royal United Service Institution, referred to the probable hindrance that will accrue to a defender from the smoke of his own guns, mainly owing to the particular nature of powder now used with heavy ordnance, and this will of course be the greater the more the guns are enclosed, the more they are massed, and the more the wind is in an unfavourable direction.

The only remedy seems to be, for engineers to avoid casemating the guns, so far as possible, and for the gunners to study coolness, to reserve their fire till they can see their object, and to rest assured that, whilst thus shrouded, the fire against them from the ships will be of more than ordinary inaccuracy.

The shell-proof accommodation of naval fortresses requires notice.

The term *shell-proof* is advisedly used in lieu of *bomb-proof*, as it conveys more clearly the nature of the protection required. The term *bomb-proof* applies to protection against vertical shell fire, *i.e.*, that from mortars, whereas the term *shell-proof* applies to protection against *all* kinds of shell fire, and it is from curved and horizontal fire that protection is now-a-days most needed.

It is considered that shell-proof barracks should exist in the immediate vicinity of the defences allotted to the different corps composing the garrison, and of sufficient capacity to accommodate with comfort the whole of the garrison.

It is impossible that troops can fight well if, when they are at rest, or not required for immediate duty, they are constantly being harrassed by an enemy's shells.

Drinkwater's famous history tells us how much during the great siege our soldiers, and the population of Gibraltar generally, suffered from want of adequate bomb-proof shelter, more particularly owing to the repeated bombardments of the enemy's gun boats, which appear to have been worked most pluckily.

It seems a pity that a hostile fleet should ever be given the opportunity of annoying in this petty way the garrison of a great sea fortress, merely from the omission to build shell-proof barracks in time of peace.

It need hardly be added that ample shell-proof storeage would also be required for the gunpowder, cartridges, shells, ordnance stores, and commissariat supplies of the fortress.

Before coming into action all appliances should of course be at hand for quickly removing disabled guns, carriages, and platforms, for replacing them with new ones, and for remounting those knocked over and not rendered inefficient.

Skilled workmen should be at hand for repairing injured *matériel*, works, and obstructions.

These repairs need not always be effected at night. Drinkwater relates how at the siege of Gibraltar the engineers rebuilt with solid masonry the whole flank (120 feet long) of Orange Bastion in the face of the enemy's fire.

In designing the sea defences of a coast fortress it would seem not at all impossible to make them too strong for their purpose, owing to a magnified idea of the capabilities of ships, and of the naval resources of foreign powers.

But the landward defences of such strongholds could hardly be too efficient, for the chances of reducing them are far more reasonable, provided the necessary military operations for the purpose can once be fairly started.

This might be brought about by only the temporary loss of the command of the particular sea or ocean concerned.

An engineer in designing a coast fortress should make himself well acquainted with all the hydrographical conditions of his port, and should know his waters even better than his shores.

He should study his intended defences from an objective point of view. He should be a gunner at heart, and should identify himself with his guns rather than with his works. He should also have strong maritime sympathies, and should be conversant with all the latest developments of naval construction and naval warfare.

In the attack of a coast fortress, an engineer on the staff of the Commander-in-Chief of the attacking fleet would clearly not be out of place; and, on the other hand, in the defence of a great fortified naval arsenal, a naval officer at the right hand of the General Commanding would undoubtedly be of much assistance.

If the principles proposed for coast fortification are carried out, the earlier and weaker kinds of iron shields now in position on the sea faces of naval fortresses might gradually be removed, and perhaps be re-erected in the Haxo casemates of the land faces, where they would be more useful.

The hitherto shielded sea guns could then be remounted in barbette, either in the same or in different positions, giving them all the training they would be capable of obtaining, and affording the gunners the protection that the circumstances of each case might call for.

### (6). On the Naval Attack of a Fortress.

The best plan for reducing a sea fortress, and for subsequently destroying the naval establishments and shipping which it may protect, is, probably, to attack it on the land side, by a siege army, as we did at Sebastopol, the navy acting, when necessary, as a base of operations to the troops on shore, and only co-operating in the attack in cases where by so doing they would undoubtedly assist the shore batteries.

For instance, supposing that the fortress lies on a peninsula, and that the land faces can be to some extent enfiladed from the sea, or supposing that portions of the land fronts can be taken in reverse from the sea, the fire of the fleet would be of much value.

In order to effect this enfilade or reverse fire, it might very likely be necessary for the sea batteries lying adjacent to the land faces to be first silenced. Thus an engagement would be brought about between the ships and the forts, but only as a step on the part of the ships towards assisting the shore forces.

At fortresses *where there are no channels to be forced nor outlying defences to be passed,* and where the forts and batteries do not guard dockyards or arsenals, it would seem unadvisable that ships should ever come within effective range of the sea batteries, except in order to injure the land faces.

Assuming, however, that at a fortress of this nature, ships actually should, for some reason, stand in and enter into a pitched battle with the sea batteries that did not lie adjacent to the land ones, and, moreover, that they not only escaped being crippled or sunk, but that they actually silenced the fire of some—or even of all—of these works, *cui bono?* It would be a very barren honor.

Until the escarps of such a fortress were breached it could not be taken. But it is quite out of the power of ships to breach masonry escarp walls, and even if they were breached, an assault of the breaches over the intervening waters, even at night, would be a most hopeless undertaking, and one certain to end in a disaster.

There appear to be no records of escarp walls having ever been breached by ships' fire, and the operations in the American civil war go strongly to confirm the idea that breaches can only be made in the sea walls of forts and fortresses by means of batteries thrown up on shore.

It seems clear, in fact, that ships, without the aid of troops on shore, can never hope to capture sea fortresses.

It may safely be accepted as a rule that ships should never engage forts unless there is some great tangible object to be gained by success—and only then if there is no alternative.

Ships do not enter the contest on even conditions. They are, so to speak, too heavily weighted to win the race. They cannot capture nor sink the fort, and, whatever the issue, they get but little credit, whilst the chances of their being themselves sunk are very great.

Where there are channels, or outlying defences to pass, as would generally be the case at all sea fortresses within which should lie dockyards, arsenals, or other valuable naval establishments, the end or object of the attacking ships is in most cases to *get past* the forts and to destroy the buildings or shipping that they are designed to protect. The attack on the forts is on these occasions merely as a means to an end, and should certainly be evaded by the ships if possible.

On the other hand, the end of the fort is purely offensive. Its business is not to protect itself, but to sink the ship.

For the ship, thick armour is indispensible. For the fort, the heaviest guns, and full play for them, are the *sine quâ non*.

Booms, and obstructions generally, of course keep the ship longer under the forts' fire, or tend to do so, and thus add to its effectiveness.

As already submitted, it would be better to endeavour to reduce all kinds of naval fortresses from the land side, in order to destroy their dockyards.

But if there should be a reasonable chance in thick weather, or in a dark night, for ships to get *quickly* past heavily armed forts guarding channels, perhaps owing to a faulty system of obstructions, and if the prize to be gained was very great, it might be worth their while, other circumstances being favourable, to make a a dash for it, and to take the chance of ever returning.

There may still, however, arise conditions which may render it absolutely necessary on the part of a nation to make a deliberate and purely naval attack on one of their enemy's great fortified dockyards, with the view of demolishing both the forts and the naval establishments.

In such a case, the whole project of attack should be thought out beforehand with great care, and precise orders should be given to each ship, and for each intended operation.

In order to draw up this project, the possession of good plans of the port, channels, and fortifications, would be essential.

In addition, a thorough knowledge should be obtained through the Intelligence Department at home, and also by means of reconnoitring expeditions and spies on the spot, of the circumstances of each fort and battery, of the systems of booms and obstructions adopted, and in fact of the defences generally, besides the purely maritime points connected with the nature of anchorage, soundings, tides, currents and winds, concerning which, of course, too much knowledge could not be gained.

As regards the artillery and works, some of the questions to which accurate replies would be valuable might be as follows:—

(*a*) Are the gunners well affected to their officers, in good spirits, and well trained?

(*b*) Are they exercised in concentrated firing?

(*c*) Are the resources of the fortress good, in point of ammunition.

(*d*) Have the engineers carefully prepared in peace time their schemes of defence against all possible methods of attack?

(*e*) What are the levels of the different works above the sea?

(*f*) Are any of them open to surprise by the gorge?

(*g*) What sort of masonry or concrete is used at each work?

(*h*) When were they each built?

(*i*) How is each gun mounted?

(*k*) What protection is there for the gunners?

(*l*) How rapidly can each gun be served and fired with accuracy?

(*m*) What guns are the iron shields and turrets (if there are any) calculated to resist?

(*n*) Are the front racers or turntables likely to be jammed by well planted blows on the armour?

(*o*) What training can each gun obtain?

(*p*) What depression is each gun capable of?

(The two last questions are very important)

(*q*) Are there enough artillerymen to serve each gun, or have they to be supplemented by line troops?

(*r*) What are the exact positions of the areas of dead water, if any?

(*s*) Is there ample shell proof accommodation?

Detailed information of this kind on all branches of the defence would be most valuable.

A scheme conceived in a spirit of fixed determination to win, and embracing in its considerations the *non*-fulfilment of some of its principal conditions, owing to misunderstandings and other accidents, but ignoring the possibility of defeat, having been matured, next comes its execution. (As the Germans say, "First ponder then risk.")

In the actual operation, all instructions should be carried out by the ships as nearly like clockwork as possible. Each ship should totally disregard the fire from a battery which she had not been told off to engage.

It is submitted that such an attack could not reasonably be expected to succeed unless, in addition to the attacker being provided with all known means for bursting, annulling, or passing the booms and other obstructions in the channel, the following conditions existed :—

1st. That the majority of the defender's guns were not above the level of 50 feet above high water mark.

2nd. That the weight of projectiles that could simultaneously be thrown at effective range at the batteries from the heavy guns of the attacking ships, from the positions taken up during the chief phases of the probable engagement, at least *quadrupled*, in each nature of ordnance, the weight of projectiles that could simultaneously be returned by the defender's heavy guns.

3rd. That the amount and thickness of armour carried by each attacking vessel, should be such as would effectually protect it against the defender's heaviest projectiles at the closest ranges at which the soundings would allow the vessel to lie.

It would be difficult to draw up any detailed regulations for the naval attack of a large sea fortress, since fortresses are so different from each other in their conditions and circumstances.

But it may be taken for granted, that no attack would succeed unless the attackers possessed a thorough knowledge of the art of fortification.

A few suggestions regarding the more primary details of a naval attack may however be ventured upon.

1. And first, as to the kind of vessels advocated for such operations. It is submitted that the following should be their main characteristics :—

(*a*) Small draught.

(*b*) Broad beam.

(*c*) Great stability.

(*d*) Low freeboard.

(*e*) Short and handy.

(*f*) Double ended, with a screw and rudder at each end, on Griffith's principle.

(*g*) Two independent sets of engines and boilers.

(*h*) No masts.

(*i*) Fair horse power.

(*k*) Great thickness of vertical armour, especially at the vital parts.

(*l*) Protection against curved and plunging fire, by deck and horizontal armour plating.

(*m*) Protection against sinking, by numerous well arranged water-tight compartments.

(*n*) The heaviest guns, and not more than two of them.

(*o*) The guns to be mounted, as desirable, either in a moveable turret, a fixed turret, or a box battery, but, in any case, to be capable of delivering a simultaneous bow fire.

(*p*) Fair coal capacity and steaming endurance.

(*q*) Good accomodation for crew.

2. Mortar boats and vessels for curved fire would not be of any practical use against properly constructed forts, containing good shell-proof accommodation.

The damage effected by such fire is always very problematical, but the expense of fitting out such vessels is certain.

3. Small unarmoured gun boats carrying single heavy guns, firing them at long ranges, and trusting to their small size for immunity from the defender's shells, would also, it is submitted, be of little good. Their fire would be comparatively harmless, and their small size, if they came within effective range, would hardly avail them much against cool, well trained, shore gunners. These boats present much greater marks than the ordinary targets such gunners are accustomed to fire at.

4. It is also submitted, that keeping attacking vessels (of any kind) *in motion*, whilst firing against forts, does not operate to the advantage of the attacker.

The vessels as a rule, present their broadsides during the whole action, and, moreover, their motion must certainly tend to magnify the inaccuracy of their fire, and so also must the constant variation of either the range or the target at which they are firing.

They can only move slowly, and probably the accuracy of the shore fire (especially at close ranges) would be but little more affected by having large targets moving slowly across their front, than if they were fixed.

Therefore such manœvures as a squadron of ships in line ahead attacking a line of batteries, whilst steaming past them over a circular or elliptical course, are deprecated.

5. It is suggested that a better plan would be for each vessel to anchor, and bring itself end-on, opposite the battery it is ordered to engage, *at as close a range as the soundings will admit*, and then to pour in its fire very deliberately. The commander of the squadron would alone be in motion, and this for the purpose of watching the varying stages of the conflict.

6. Great stress should be laid on ships standing in close. The normal inaccuracy of their fire is thereby reduced to a *minimum*, and, generally speaking, fewer of the defender's guns can be concentrated on them, whilst the ships are more likely to pierce or shake his shields and turrets, if he has any.

7. Passing within the five fathom line should be an object with the attackers, since a defender's batteries are generally designed with reference to this line.

8. All dead water should be carefully taken advantage of, as was the case at the attack on Sebastopol. What little success then accrued to us was due entirely to this fact.

8. Mere bombardments of coast forts or batteries are totally useless.

10. Even bombardments of the dockyards, or naval establishments of a fortress from long range, say 5,000 to 8,000 yards, supposing them to be thus attainable, would probably effect singularly little injury in comparison with the efforts made and the risks run for the purpose. Any damage made by shells in dockyards could be repaired with no great trouble. It is submitted that the only sure way of effectually destroying a dockyard would be by capturing it, and then by blowing up the docks, as was done at Sebastopol.

### (7). Concluding Remarks.

It was at first intended by the writer to sum up the various points on which he has made suggestions on coast fortification and the naval attack of fortresses, but, as this would afford some chance of weakening the force, or distorting the sense of the various statements made, he has thought it best to abstain from doing so.

The paper does not profess to touch on every point connected with naval fortress warfare. The subject is a very large one, and branches of it are continually being ably treated on from various points of view by officers.

The writer regrets that the substance of this paper is not based on any experience of the warfare to which it refers, but only on reflection induced by observation and reading, and on information gained during ordinary military engineer peace service.

Perhaps, however, it may be the means of obtaining valuable opinions from officers who actually have been engaged in coast fortress operations.

A.P.

7. All dead water should be carefully taken advantage of, as was the case at the attack on Sebastopol. What little success then accrued to us was due entirely to this fact.

8. Mere bombardments of coast forts or batteries are totally useless.

10. Even bombardments of the dockyards, or naval establishments of a fortress from long range, say 3,000 to 4,000 yards, supposing them to be placed advantageously, would probably effect singularly little injury in comparison with the efforts made and force in use for the purpose. Any damage made by shells in dockyards could be repaired with [illegible] rapidity. It is submitted that the only sure way of effectually destroying a dockyard would be by capturing it, and then by blowing up the docks, as was done at Sebastopol.

(12.) Concluding Remarks.

It was at first intended by the writer to sum up the various points on which he has made suggestions for naval fortification and the naval attack of fortresses; but as this would afford some chance of wearying the [illegible], in discussing the points of the various [illegible], he has thought it best to abstain from doing so.

The paper does not profess to touch on every point connected with naval fortress warfare. The subject is a very large one, and branches of it are continually being ably treated on from various points of view by others.

The writer suggests that the substance of this paper is not based on any experience of the warfare to which it refers, but only on the theories induced by observation and reading, and on information gained during ordinary military and naval practice.

Perhaps, however, it may be the means of eliciting valuable opinions from others who actually have had personal experience of such operations.

A. G.

# PAPER XVIII.

## ON A BRIDGE MATERIAL

PROPOSED BY CAPTAIN DURELLI, OF THE ITALIAN ENGINEERS,

FOR THE

## ENGINEER TRAIN OF THE ITALIAN ARMY.

By Lieut.-Col. E. R. James, R.E.

In Italy it was formerly the duty of the artillery to select the positions of bridges, and the pontoon train was in charge of this arm, but now the establishment of the means of communication of the army has been entirely confided to the engineers, who originally only completed the roads and ramps by which access to the bridges was gained.

For the construction of bridges in the first line a pontoon equipage is attached to each army corps and provided with material, on the pattern adopted in 1860, for 150 metres of bridge. For crossing large water courses in the front, of which the nature of the bottom and the velocity of the current vary, and expedition is required, it is necessary to have a specially trained body of pontooners, and the material in their charge cannot conveniently be separated to make it available for passing those minor obstacles which troops encounter on the march, such as ditches and canals. The sapper companies following the divisions of the army corps are entrusted with this latter duty. To fulfil this charge they are not at present provided with any materials, and are obliged to depend on the resources which may present themselves at the site selected for a bridge. When the commercial centres or the depôts of material are distant, and the country is without suitable trees, the difficulty is the greater, and either valuable time may be lost in searching for the material wanted, or the men may be required to work for many hours after a fatiguing march.

When the material has been collected it is almost always of differing forms, dimensions and natures, and has to be sorted, and the supports and flooring of the bridge designed, cut and fitted. A thousand things have to be done, and the banks have to be formed into ramps. All this has often to be accomplished in one night, and before dawn the column of troops may have to advance over the bridge, the very sappers who have made it having to accompany the march.

Sometimes more than one bridge has to be constructed, and the difficulties increase because the engineer brigade (already weakened by the loss of the men forming the telegraph section, &c.) has to be sub-divided, the infantry working parties being only useful in forming the ramps. In Italy, especially in the Po valley, there are so many ditches and canals that the probability of more than one bridge having to be constructed is great.

Without a bridge material the captain of an engineer company cannot depend with certainty on being able to construct a bridge at any given point not yet reached by the advanced guard of the army corps.

Let us, therefore, consider how troops should be exercised in peace time in bridging a stream with chance materials. Engineer schools are at present provided with a certain quantity of materials which they employ in constructing bridges of various kinds, but the use of such materials can only give an imperfect idea of the contingencies which may arise in warfare. On the other hand, the engineer companies have to be instructed in so many things that a very short time can be devoted to their training in bridge construction with chance materials. In England this argument is stronger than in Italy, as our companies can only be trained at the School of Military Engineering at long intervals, they being at other times employed profitably at various trades. In Italy, and on the Continent generally, on the contrary, the engineers are to a large extent employed in the practice of military engineering alone.

With the little time and material available, the soldier can at most be taught at the school of instruction the method of forming two or three different sorts of trestles, and two or three different ways of constructing a flooring for a bridge on trestles, casks, boats, &c., and it is important that these examples should be of such a typical character that he may take them as guides when he has to deal with chance materials in warfare. But a bridge formed with materials collected on the spot will invariably require, after they have been got together, several hours work to shape and fit the different parts, and to cut the ramps. In modern warfare one of the principal factors in ensuring success is quickness of movement, and it has often happened, and probably will again, that the non-completion of a bridge delays the advance.

In the campaigns in Italy in 1859 and 1866, the necessity of giving a special bridge material to some of the engineer companies in front was seen; but most of the companies depended on chance materials in the numerous crossings which were established. After the campaigns, in spite of the proved advantage to sapper companies of a regular bridge equipment, the material was withdrawn, and the rule that chance materials should be depended on was re-established.

Among the other lessons of the war of 1870-71, it was clearly shown that an army of operations should above all be in readiness to establish its communications quickly and securely.

This has led to the proposed establishment in the Italian service (as in the Prussian) of an equipage for each division for the formation of a bridge 36½ metres long, in addition to an equipage for 122 metres with the reserve of the army corps, while with the troops in the first line, in countries where large rivers exist, there will also be the main equipage for a bridge of 150 metres.

Several of the officers occupied in the organisation of the engineers in Italy have proposed to sub-divide the different duties of this corps. Among the pamphlets published on this subject during the past year, one entitled *Considerazioni e proposte sull'ordinamento dei reggimenti del genio*, contains a proposition that every engineer brigade attached to a division of an army corps shall be supplied with the Birago equipment for the construction of a bridge 26 metres in length, and that the two park wagons now given to each company shall be abolished and replaced by simple general service carts loaded with the entrenching tools now considered necessary in the field.

These propositions have been favourably received, because if they be adopted the sapper companies would be in a position to carry out one of their special duties, and would not only be able to throw a bridge over a ditch, but could cross a small river or any other obstacle. But as the Birago equipment needs four park wagons and two carts for each brigade of two sapper companies, there is some opposition to its adoption. It is, however, true that the proposition to abolish the park of the two engineer companies would diminish the equipment of the train by four wagons; but as it would be necessary to give at least one cart to each company for its tools, the actual reduction in the number of carriages would only be two, and, on the whole, the adoption of the Birago equipment would cause an increase of four carriages to the brigade.

But it has been doubted whether the Birago 26-metre bridge will meet all the requirements of the sapper companies. For the pontoon companies, who only have to deal with wide rivers, it would always be useful in the establishment of piers, and the interval could usually be bridged by boats or other means. But the sapper companies have rarely to deal with very wide rivers, and the gaps they have to cross have frequently very elevated banks where the road level on either side must necessarily be very much above the water level. They have, in fact, very often to construct bridges where they are obliged either to adopt special means for establishing the piers, or to undertake heavy excavation to make the approaches. In such cases the Birago material would only be serviceable for the flooring and central portion of the bridge.

The objections raised to the Birago equipment, and the desire on the other hand for the adoption of a bridge material suitable for all needs has brought the subject much under notice. It is necessary that the following conditions shall be satisfied :—

1. The material must be sufficient to form a bridge from 20 to 30 metres long, without supports in the middle, and be strong enough to carry the ordinary carriages which follow an army corps.

2. The number of carriages should be reduced to a minimum, and certainly should be less than the number required for the Birago equipment.

3. The cost should be as small as possible.

The first condition may be satisfied by the adoption of the American system, the frame work of the bridge being formed by two parallel girders, and, by a suitable arrangement, the parts of the girders may, when they are taken to pieces, become parts of the carriage which carries them. Thus each part of the material, except the wheels and axles, may have a double use, and should a bridge have to be left standing a short period, the wheels and axles would be useful for the transport of any chance material which could be obtained to replace at leisure the regular bridge equipment.

On these considerations Captain Durelli, of the Italian engineers, in an article in the *Giornale di Artiglieria e Genio*, proposes the adoption of an equipment of which a description (*see Plate*) follows :—

The bridge is composed of 5 sections of floor, each 6·92 metres long, and of two girders 25·44 metres long.

The sections of flooring are similar to those of the Birago equipment, and are formed by five joists, the flooring boards, and two ribbon pieces over all.

Each girder (*Figs.* 2 and 3) is formed by four rows of horizontal baulks, Birago pattern, joined together by a network of bars crossing at an angle of 45°.

The height of the girders is 2·12 metres, and their maximum length 25·44 metres. The section of each beam composing the upper and lower longitudinal rails is 0·117 metre × 0·16 metre, and that of the cross-bars 0·29 metre × 0·04 metre.

The beams composing the longitudinal rails are joined in the manner shown in *Fig.* 4.

At the extremities of the girders are uprights *b b* (*Fig.* 2); these may be placed either at the extremities of the entire length of 25·44 metres, or at the extremities of such portions of the length of girder as may be used in the bridge.

The ends of the flooring joists rest on cross beams, 0·23 metre × 0·16 metre in section, these in their turn being supported by the lower longitudinal rails of the girders.

The cross beams at *d d* (*Fig.* 2), placed near the middle of the bridge, jut out beyond the girders to a distance of 1·20 metres, to support the iron stays *s s* (*Fig.* 3), which serve, as well as those at *c c* (*Fig.* 2) placed at the extremities of the bridge, to prevent oscillation. The stays are bent at their ends, and secured by staples, as shown in *Fig.* 3. When it is desired to add strength to the bridge the cross pieces are increased from four to six in number, with corresponding stays.

The lower rails of the girders are also tied together by iron bars placed diagonally under each compartment.

The extremities of the girders should have a bearing on the banks of not less than a metre, on a prepared bed, consisting of three or more sleepers *a*, *a*, *a* (*Fig.* 2) from 3·5 to 4·0 metres long, held in place by strong pickets (*p*). Iron stays (*c*) are fixed to the ends of the sleepers.

The pickets are in pairs transversely, one on each side of the lower rail of the girder, their heads being coupled by an iron plate, as shown in *Fig.* 5. Wedges driven between this plate and the upper surface of the girder rail give rigidity to the ends of the bridge.

When the bridge is packed for transport, pickets (*Fig.* 8) are employed to secure the sides of the load.

Cross beams *e* (*Fig.* 2), similar to the cross pieces on the bridge at *d d*, are placed against the ends of the girders.

In calculating the dimensions of the several parts, the following data are taken :—

1. The network of the girders is formed by chesses forming the flooring of the Birago bridge, 3·27m. × 0·29m. × 0·04m.

2. The bridge must be strong enough to bear ordinary service wagons.

3. The girders must be capable of being made about 26 metres long, as well as shorter lengths.

The chesses forming the net work cross at 45° and, in consequence, the height of the girders must be 2·12 metres, and the maximum length 25·44 metres. As the feet of the cross pieces will be 4·24 metres (see *Fig.* 1), the available lengths of bridge for different circumstances will be multiples of this, *i.e.*, 4·24m., 8·48m., 12·72m., 16·96m., 21·20m., and 25·44m. If the strength of the girders be calculated from the maximum length of the bridge, the lesser lengths will, it is evident, give an excess of stability beyond the figure obtained.

As regards the load which the bridge should be able to carry, treatises on military bridges lay down the rule that a bridge which is strong enough for infantry in fours will bear the ordinary carriages following an army. Let us, therefore, assume that 850 kilogrammes for each linear metre, or 21,624 kilogrammes on the whole bridge uniformly distributed, must be the load the bridge should bear.

### *Weight of the flooring.*

The total weight of the girders being 25·44 metres, and the Birago baulks composing them being 7·08 metres long, each section of flooring is 6·92 metres long, and thus the girders have to support three sections of this length, and two others 2·34 metres long. From these data, the total weight of the flooring, inclusive of the four cross beams, may be calculated as 3,926 kilogrammes, or 154 kilogrammes per linear metre of bridge.

### *Weight of the girders.*

| | |
|---|---|
| The lattice work of each girder is formed with 24 pieces, each weighing 18 kilogrammes, and their total weight in the two girders is, therefore... | 864 kilogrammes |
| The upper and lower rails are formed by Birago baulks in continuous pairs, and their section is 0·234m. × 0·16m. The weight of a Birago baulk being 65 kilogrammes, the four rails have an aggregate weight of ... ... ... ... ... | 1,868 „ |

Each cross bar is fixed at its extremities, and at its junction with the bar inclined to it by two bolts. The total weight of these in the bridge is about ... ... ... ... ... ... 50 kilogrms.

The weight of the two girders is, therefore ... 2,872 „

Each of the girders must therefore support :

$$\frac{21,624 + 3,926 + 2,872}{2} = 14,166 \text{ kilogrammes,}$$

or, per linear metre of bridge $\frac{14,166}{25 \cdot 44} = 557$ kilogrammes.

*Strength of the girders.*

Applying now the formula for the strength of beams, the upper and lower rails of the girder have to support about 63 kilogrammes per square centimetre of section, or nearly $\frac{1}{15}$th of the weight which larch timbers will bear. This, which is diminished by the bolt holes, does not seem an excessive margin of safety in a temporary bridge.

*Strength of the bars of the lattice work.*

The strain on these is calculated at nearly 43 kilogrammes per square centimetre, or considerably less than the strain of 60 kilogrammes allowed the rails.

*Strength of the bolts.*

The severest strain is on the bolts which unite the corresponding bars at the ends of the lattice work. There are 12, and they have to support together 9,990 kilogrammes. The strain on each is then 2·65 kilogrammes per square millimetre, or about half the strain which is admissible in practice.

It is, therefore, evident that the bridge is amply strong to bear any strain it will be subject to.

*Method of construction of the bridge:*

If the obstacle to be crossed be less than 10 metres wide, the lower rail of the girder is first thrown across by any of the ordinary means employed to throw beams across an opening, and the bridge is built upon it in site ; but if the obstacle exceeds 10 metres wide, the girder is built up before it is thrown over, proceeding as follows :—

When all the materials are unpacked, the two girders are built up on the bank, the front ends being supported on trestles, and the rear ends on one or more pairs of the wheels and axles belonging to the carriages of the equipment, an inclined way being prepared to run the girders out, as shown in *Fig.* 6.

When the girder is made up, a temporary platform should be securely fixed at *b b* (*Fig.* 6), on which a number of men can be assembled to counterbalance the weight of the girder while it is run out.

It is unnecessary to give the calculations in detail to show that this arrangement is perfectly feasible and practicable. The author of the Italian article states that the bridge can be constructed in this manner without the aid of shears or temporary floating supports.

*Disposal of the material for transport.*

The weight of the bridge is thus made up :—

| | | |
|---|---|---|
| 5 sets of flooring ... ... | 4,435 | kilogrammes. |
| 8 beams and 4 uprights ... | 1,436 | " |
| 2 girders complete... ... | 2,782 | " |
| Total ... ... ... | 8,653 | " |

In order to carry this easily it is divided between four carriages, each of which carries 2,169 kilogrammes; adding to this the weight of the front and rear wheels, axles, &c., ropes, bolts, and nuts, and all the necessary tools, the total weight of each carriage loaded is 2,500 kilogrammes.

Each carriage carries—

17 baulks.
45 chesses.
2 beams.

The front axle body is similar to that of the engineer park carriages, and the junction with the rear axle body is made in the ordinary manner. The box *a*, and the casing *b*, form part of the rear body (*Figs.* 7 and 8); the former contains the bolts, nuts, nails, screws, and small stores. The cross bars at the bottom of the box *a* have loops at their ends, through which pass the uprights of the iron framework, described later. This arrangement admits of the limber box being detached from the carriage.

The rear wheels have a diameter of 1·48 metres, the same as the park wagons. Above the axletree an iron framework is fixed with holes on the upper surface. (*Fig* 8. *a.*)

To connect the parts which form the wagon box, iron frames divided into compartments, are used (*Fig.* 9). There are three of these in the length of the wagon, one over the rear wheels, and two corresponding ones at the ends of the box over the front wheels. They are fixed by bolts and nuts to the holes in the surface of the iron framework over the axletrees.

The frames being fixed, two beams and six baulks are placed in the lower compartment; in the second compartment ten baulks are placed, and eleven rows of chesses in each of the small upper compartments. The remaining baulks, and the ropes, spades, hammers, and other tools occupy the space between the upper compartments, and lastly the picket posts are placed in the rings forming the ends of the horizontal bars of the framework.

A roller *c* (*Fig.* 7) is fixed on arms placed above the rear wheels for the purpose of facilitating the extraction and packing of the material.

The total length of the loaded wagon is 8 metres; the wheelbearing surface is the same as that of the park wagons, 3·50 metres.

The Italian author proceeds to a comparative view of the advantages of the Birago equipment, and of that he proposes, in which he claims many advantages for the latter. A bridge, 25 metres long, can be built with a minimum of labour in the shortest time, in situations where only parts of the bridge could be made with the Birago material. Four carriages carry a length of bridge material requiring six with the Birago equipment. All bridges being made in the same way, the instruction of the sappers is much simplified by using the material proposed. The material is of such a simple character that broken or lost parts can easily be replaced.

The author also claims that in the event of a bridge longer than 26 metres having to be made, the equipment would lend itself to the purpose better than the Birago equipment; but as we have not had the advantage of studying the details of the latter, we are unable to enter impartially into the merits of this question.

Some of the officers, whose opinion on his equipment Captain Durelli asked for, advised him to add a boat of the 1860 pattern to his girder bridge equipment for a sapper brigade. This boat would serve as a floating support in long bridges, at points where the velocity of the stream or the nature of the bottom does not allow of a fixed support; it would serve, also, in passing the girders from the one bank to the other, and for general purposes in establishing the bridge.

If this boat were added, the number and weight of the proposed carriages would be modified. All the material would be divided among five carriages, four of which would each carry 12 baulks and

44 chesses, and one the boat and 20 baulks. The weight of the first would be diminished by 325 kilogrammes, and would, therefore, be about 2,200 kilogrammes.

The carriage with the boat would weigh—

| | |
|---|---|
| For the 20 baulks ... ... ... | 1,300 kilogrammes. |
| " boat ... ... ... ... | 560 " |
| " oars and boat fittings ... | 340 " |
| Total ... ... | 2,200 " |

The method of packing for transport when five carriages are used is shown in *Figs.* 10 and 11.

In conclusion, the author gives for comparison the following details of the Prussian bridge equipment for an army corps :—

The separate equipment for each of the two divisions comprises—

| | |
|---|---|
| Carriage for trestles ... ... ... ... | 2 |
| Carriage for boats and baulks... ... ... | 6 |
| Carriage for tools, &c.... ... ... ... | 1 |
| Total ... ... ... | 9 |

The bridges which can be made from this material are of a maximum length of 36·50 metres.

The equipment for an army corps comprises 33 carriages, which carry material for 122 metres of bridge. The three equipments together, therefore, will form a bridge 195 metres long.

In Italy the pontoon train of the army corps has 30 carriages carrying material for a floating bridge of 150 metres. If the train of four carriages were added for the construction of fixed piers at the ends of the bridge, with the addition of four supports made from material obtained locally, a bridge 192 metres long could be made, with a train of 34 carriages. In Prussia, on the other hand, 42 carriages are employed to make a nearly equal length ; but it must be observed that this is without aid from material obtained locally.

Captain Durelli's system has not yet been tested practically.

E.R.J.

ansport.
e of $\frac{1}{50}$.

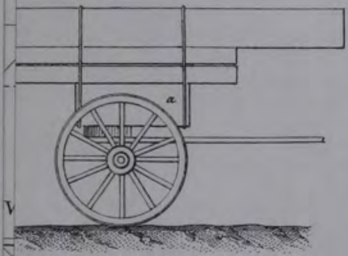


Fig. 9

Iron Framework.
Scale $\frac{1}{20}$


Method of Packing when 5 Carriages are used.

Fig. 10

Balks and Chesses.

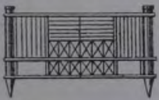

Fig. 11.

Iron Framework.

# PAPER XX.

# ROYAL ENGINEER PRIZE ESSAYS.

## 1878.

SUBJECT:—

*Railways: their Use and Maintenance in time of War, the Art of Fortification in connection with the Defence of Railways, and especially Railway Junctions, and the Organisation of a Railway Corps.*

At the Corps Meeting in 1878 it was decided, on the recommendation of the referees,* that (with the consent of the authors) extracts should be selected for the *Professional Papers*, from three of the essays which were considered to be of equal merit.

The extracts selected are included in this number. As it was necessary to limit the extent of them, it must be understood that they are not intended to contain a complete essay on the subject above propounded, and that neither do they do justice to the individual essays. They are almost entirely confined to matters of fact and of detail, such as was supposed would be of use to the Corps generally in this condensed form; and where any propositions of the authors are introduced, it is for the same reason, and not implying any opinion on their merits.

T.B.C.
C.S.H.

* The referees were Major-Generals T. B. Collinson and C. S. Hutchinson, and the late Colonel R. Home, C.B.—Ed.

REFERENCE:

| Letter | Name of Author. | No. and Motto of Essay. |
| --- | --- | --- |
| *a* | CAPT. D. O'BRIEN, | No. 56, "*Vigueur de dessus.*" |
| *b* | " T. J. WILLANS, | " 101, "*Fortiter sed apte.*" |
| *c* | LIEUT. W. H. TURTON, | " 729, "*Perseverance.*" |

# CONTENTS.

# LIST OF WORKS ON THE SUBJECT.


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Les chemins de fer au point de vue militaire, traduit de l'allemand par Costa de Serda, Paris, 1868.

De l'emploi des chemins de fer en temps de guerre, tradnit de l allemand (Anon). Paris, 1869.

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Die Eisenbahnen im Kriege von Wilhelm Basson, Ratibon, 1867.

Règlement général de 1re Juillet, 1874, pour les transports militaires par chemins de fer, Paris, 1874.

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XII.—1865—Railways strategically considered, by Capt. H. W. Tyler, R.E.

VII.—1866—Coast railways and railway artillery, by Lieut. Walker, 79th Highlanders.

Wright's artillery railway and gun carriage, by Mr. Wright, C.E.

XVII.—1874—Field railways and their general application in war, by Captain Luard, R.E.

XX.—1876—The German railway regiment, by Lieut. Rawson, R.E.

XXI.—1876—The supply of an army in time of war, by Col. Hazenkampf, Chief of the Staff of the Russian Guard Corps, translated by Captain Clarke, R.A.

Notes from Minutes of the Proceedings of the R.A. Institution.

VI.—Translation from Prussian regulations for military transport, Berlin, 1867.

1872—The use of railroads in time of war, by Major-General Sir David Wood, K.C.B.

The armed strength of Austria, by Captain Cooke, 22nd Regiment, Part II. London, 1874.

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And several papers in the

Revue Militaire de l'Etranger.

Spectateur Militaire.

Mittheilungen über gegenstände des Artillerie-und Genie-wesens (Wien).

Extracts from the Proceedings of the Royal Engineer Committee.--(c).

# USE OF RAILWAYS IN WAR.

## SECTION 1. GENERAL CONDITIONS.

*Example of use of Railways in War.*

During the siege of Paris one railway for some time fed the (German) army of, in round numbers, 200,000 men, brought up the siege materials, and reinforcements averaging 2,000 to 3,000 men a day, and even, at one time, fed Prince Frederick Charles' army as well, with very slight assistance from the resources of the exhausted theatre of war.—*Hamley's Operations of War*, p. 41.—(c).

*Use of Telegraph.*

General McCullum, after his great experience in the American war, declared that a single line of railway with the telegraph was better than a double line without it.—(c).

*Opinion on Railways—American and Danish Wars.*

Of the American War it has been said, and we think justly, "*En définitive, toute cette guerre a consisté à se disputer les chemins de fer.*" Two reasons may be given for this—firstly, railroads were very plentiful and ordinary roads very scarce; secondly, owing to the thinly populated country they were often the only means of obtaining provisions; anyhow, the fact remains that both sides considered them of paramount importance, and attacked and defended with unusual vigour. In the Danish War, also, despite the insufficiency of the rolling stock and the badness of the lines, they were much employed by both Prussians and Austrians for concentrating their troops; on the other hand, had the railway in rear of the Dannewerke been completed, the Danes need never have abandoned that, their only defensive position.—(c).

*Further Examples in late Wars.*

The first considerable transport was in 1849, when a Russian corps of 30,000 men, dispersed in Poland, was conveyed to Göding to join the Austrian army. In the following year 75,000 men, 8,000 horses, and 1,800 carriages were taken from Vienna and Hungary to Brunand Olmütz in 26 days. Passing on to the Italian War of 1859, the Paris and Lyons Company conveyed over 8,000 men and 500 horses daily for some time (20th to 30th April), and this without interrupting the ordinary traffic, and fortunately without any accident. It has been calculated that it would have taken six times as long to have concentrated the same force in Piedmont by ordinary marches; and here we have the first instance of railways seriously influencing a campaign. The Austrian transports were not managed so well; perhaps, the most satisfactory was that of the 1st Corps (about 40,000 men and 10,000 horses) from Prague to Verona in 14 days; by ordinary marching it would have taken four or five times as long, the men not arriving on the theatre of war till after peace had been concluded. Later on in the American conflict, Hooker's corps of 23,000 men, with artillery, was conveyed over 1,200 miles in seven days; three months would otherwise have been required. In the Seven Weeks War the Germans were able to transport as many as 197,000 men, 55,000 horses, and 530 carriages in 21 days, or over 6000 men a day for three weeks. Lastly, we have the Franco-German War of 1870-71. In ten days the Eastern Company of France had carried to the frontier 186,620 men, 32,410 horses, 3,162 guns or carriages, and 995 ammunition wagons. The German railways transported to the frontier 42,000 men *daily* for nearly two weeks; they, however, were able to utilize five different lines.—(*c*).

*New Danger to Frontier Fortresses.*

One of the first effects of railways should be to enable large armies to take the field much sooner after war is declared than they could formerly do, and the campaigns of 1866 and 1870 show that such is actually the case. Now, since this is equally true for both sides it might be supposed to matter little; such, however, is hardly the case; at all events, one important deduction will be admitted—that in time of peace frontier fortresses must be more fully prepared for a siege than was formerly necessary.—(*c*).

*Use of Railways for collecting Troops.*

Railways may often be useful in bringing together detached troops before a battle. Napoleon's words are—"*Quand on veut livrer bataille il est de régle de rassembler toutes les forces, de n'en négliger aucune; un bataillon quelquefois décide d'un journée,*" and how many battalions might not railways collect on the eve of a battle. True to this principle, the day before the battle of Custozza the Archduke Albert brought up Scudier's brigade to Verona by railway, without which it must have remained away. It was also by railway that, in 1863, Sherman was able to succour Rosencranz before the battle of Chickamanga. Railways, however, must not always be depended upon. Before the battle of Woerth the Prussians blew up a railway viaduct on the line between the two French forces, and this was partly why McMahon did not receive his expected reinforcements sooner."—(*c*).

*Use of Railways for Retreat.*

Railways are often useful in enabling a rapid retreat, particularly after a hard day's battle when the enemy would be too much exhausted to seriously molest it. Shortly after the battle of Sadowa, Marshal Benedek retired three corps by railway from Olmütz to Vienna. In this case the Prussians were, perhaps, to blame for not having cut the line."—(*c*).

*Victualling of Paris*, 1870.

During the Franco-German war Paris received by the Western Railway alone as much as 72,442 tons of provisions, and 67,716 head of cattle during the 35 days before the investment, without which it would have been utterly unable to have stood such a long siege. In revictualling Paris, also, the railways, though much restricted by the Germans, brought in as much as 155,955 tons of provisions, and 42,580 head of cattle in 20 days."—(*c*).

*Tactical Use of Railways.*

We have now seen several ways in which railways will influence the strategy of the future; the question naturally suggests itself, will they influence tactics also? We mean can they be utilized to reinforce troops actually engaged in battle, and if so, how may this bear on the choice of future battle-fields? Experience certainly answers the former question in the affirmative. At Montebello the Italians,* and at Magenta the Austrians received numerous reinforcements by railway, and at the former they were certainly the cause of Count Stadion retreating when he did.† Again, speaking of the battle of Bull's Run, Colonel Hamley says "the defeat of the Northern Army was mainly accomplished by the attack of a brigade brought on the field by the Manasses Railway from the Shenandoah Valley." There is, however, a later and more important example—throughout the battle of St. Quentin in 1870, the Germans received supports by railway, without which it is doubtful whether they could

* The French Staff deny this, but Gyulai mentions it in his report.

† Jacquin writes sarcastically, *L'autorité militaire ne sut pas tirer parti d'une circonstance si exceptionelle et si favorable*, p. 133.

have gained a victory, and had the French made the same use of their railways at Forbach, it is, at least possible, they might have saved a defeat.—(*c*).

*Danger of a Railway dividing Bodies of Troops.*

The Franco-German War affords an instructive instance of this. After their early defeats the French were desirous of bringing up some of the troops at Chalons (Canrobert's corps) to reinforce those at Metz; the Germans were fast approaching, so time was of consequence; the railway was at hand, and was, unfortunately, used, for *whilst the transport was going on* the line was cut by the Germans; part of the troops reached Metz, part returned to Chalons, and the corps thus separated by a few Uhlans was not again united. Had the troops marched by road the Germans were not in sufficient numbers to oppose them, and they would probably have reached Metz in safety.—(*c*).

*Concentration of Troops for War, and Advance to War.*

It should be borne in mind that the concentration of forces *for* war, and the advance of the army *to* war, are quite distinct operations, and can only be executed in the above order. In 1870 the French sent *soldiers* to the frontier with great speed, but the *army* took a long while to organize; the Germans, on the other hand, occupied a certain time in quietly organizing the various army corps at some distance from the frontier, and only moved to the front when that was complete.—(*a*).

## Section 2. The Embarkation.

*Time of Arrival at Station.*

Each battalion should arrive about half-an-hour before the time of the train's departure (sending its baggage, &c., on in advance). If it comes later there is a chance of its not being ready in time; if earlier, the station is needlessly occupied.*—(*c*).

*Want of Organization in the French War of* 1870-1.

General Vinoy, in his account of the operation of the 13th and 3rd army corps, quoted by Jacqmin, says:—"The departure of troops by rail has presented many and great difficulties in the late war. If, in the army, this part of military instruction is yet incomplete, it must be admitted that the staffs of the great railway companies have also something to learn. In addition, the arrangements, as at present existing, of our railway stations tend to

* These remarks seem so obvious that it is hardly credible that the first of the late French transports reached the station over three hours before the time, and were there distributed, causing immense confusion (Jacqmin, p. 114).

increase the inconvenience arising on both sides from want of practice. They answer well enough for commercial purposes, but

*   *   *   *   *   *   *   *   *

are faulty as regards military requirements. The narrow platforms are choked with horses and carriages; the lines, where endless trucks are accumulated, can neither accommodate empty trains coming in to be loaded, nor carry away those that are full; the manœuvering is incessant and the delay great. The personal staff, which has remained the same as usual, is rapidly demoralized, and thenceforth there is neither regularity in departure, security on the journey, nor certainty in time of arrival. The long wearisome delays in the station tire the soldier and produce a bad effect on the troops."

Jacqmin remarks on this that the confusion and delay were mainly due to the military authorities, who made the platforms places for distribution of stores, and even camping grounds. At Paulin station, with a platform 300 yards long, and a line on each side, a train of artillery was loaded each hour on alternate sides, and this went on for weeks; but when troops are expected at 12 and come at 4, and a squadron of cavalry comes in place of a battalion of infantry, all arrangements are upset.—(*a*).

*Rules for Embarkation.*

The "Field Exercise" for 1877 gives in detail the rules to be observed in the embarkation and disembarkation of the different arms.—(*a*).

*Space required outside Embarkation Stations.*

It would be better to use a smaller station more easily got to than a large station without room for troops outside. A roadside station with a field close by, lying next outside a great railway centre, would probably be able to despatch more trains than the central station. There would be ample room for the formation of the troops and proper collection of baggage. Men could be kept more in hand, the general tendency to noise increasing with crowding, and there would be less trouble from sightseers, &c.—(*a*).

*Ramps for Horses.*

The train might have to be loaded (or unloaded) at small stations, or even where there is no station at all, and then some kind of ramp would be absolutely necessary. A temporary wooden one, such as the Prussians erected at Rendsburg in the Danish War, could easily be made. We, however, prefer some kind of *mobile* ramp, such as was largely used by the Germans in their last war—an inclined plane and wheels. Two of these might be carried with each train, thus enabling it to be independent of station platforms. Such movable ramps have been largely introduced. As early as 1869 special horse ramps had been introduced into Russia on the proposal of General Annenkoff. Some complaints having been made, they were carefully tested at the autumn manœuvres of 1876, and found to answer perfectly (*Invalide Russe*, 6th September, 1876). We regret not being able to give a sketch of these. In the report on Indian railway transport, the horse ramps advocated consist of two skeleton sides, with planks placed across (of unequal thickness to prevent the horses slipping). Such appears *practically* a good method, for the planks and sides could easily be improvised, if not carried with the train. In the latter case the planks would be useful in heightening the sides of low trucks, which is necessary before horses can travel in them safely. With artillery, temporary ramps could be formed of beams or rails; *cranes* might also be used, and would be necessary if the wagons had fixed sides. According to the Pester Lloyd (20th June, 1877), each Austrian Railway Company had been ordered by the Minister of Public Works to provide a certain number of light movable cranes for unloading guns and carriages. They had been tried and found to answer very well. Special *girders* are, however, best, and should be carried with the train; a gutter-like shape (U) would prevent the wheels running off. In the Delhi experiments an H shaped girder was tried of dimensions $10'' \times 5'' \times 14'$, weight 400lbs., and was found to succeed very well. Such girders would, of course, vary in weight, the heaviest for siege guns being kept with the siege train. Though always desirable, horse ramps and girders are only absolutely necessary when near an enemy, and the line is liable to be cut.—(c).

*Embarkation (Indian Experiment).*

As regards ordinary embarkation, cavalry should arrive at the station about one hour before the train starts, and artillery about $1\frac{1}{2}$ hours, though the actual loading would take much less time. In an interesting experiment at Delhi (29th January, 1876), an entire 40-pounder battery, "consisting of three 40-pounder Armstrong guns, two $8''$ and two $5\frac{1}{2}''$ mortars, with 7 wagons, 2 store carts, 134 bullocks, including camp equipage, baggage, &c., fully equipped for active service, were embarked and ready to move in 40 minutes." A squadron of the 10th Hussars occupied 39 minutes in embarking, the unloading and fixing horse ramps took only $2\frac{1}{2}$ minutes, and the dismantling and unloading them $1\frac{1}{2}$ minutes. Colonel Hamley gives 25 minutes for the loading of a cavalry, and 30 minutes for that of an artillery train.—(*c*).

*Horses in Trucks.*

The number of horses in each truck would vary with its size from four to nine. It has been much disputed whether they should stand along the wagons or across them; perhaps the Austrian method is the best, where they stand parallel to the rails, with their heads towards the centre of the wagon. The saddles had better be taken off and packed in separate carriages, except for short journeys.—(*c*).

*Experiments in Russia—Temporary Station.*

When it is thought necessary to concentrate a large body of troops (other than infantry) at a small station, or where there is no station at all; extra lines must be laid down, and a *temporary* station formed, where the trains can be shunted to unload. Some practical experiments were made in Russia a few years ago on this subject. We quote the details of one from the *Invalide Russe*, 29th October, 1874. The station, it was thought, should enable 24 trains to be unloaded a day; the Lozof and Sebastopol line offered the use of their material to the government, so 12 officers and 500 men under General Annenkof were ordered to form a 'terminus' station near the latter place. Altogether 9,236 metres new lines, and 27 points and crossings had to be made; it took 32 working hours.—(*c*).

*End Loading.*

The advantages of the end system are:

1. The train can load or unload anywhere on the line, even in a tunnel, independent of the embankments or cuttings on either side. This is important, as through some part of the line being destroyed the train might be stopped in unlooked for positions; moreover, near an enemy, in a deep cutting or tunnel, would be just the place to unload a train, if possessed of the high ground on each side.

2. There being a continuous flooring along the whole train, the guns and carriages can be easier packed, and more carried than if they had to be divided among separate trucks.

3. The loading takes only one-half to two-thirds the time of the side loading for cavalry and artillery; for infantry a trifle longer. (See the Indian Railway Transport Report).

The defects are:—

1. For commercial purposes; since the 'side' system must be exclusively used, the other as well is worse than useless, as it weakens the wagon unnecessarily.

2. It would involve considerable alteration in all existing roll-

ing stock. Sir Charles Reid's Committee advocated this being partially done on the Indian lines.—(*c*).

*Loading of Stores.*

The transport of stores of all kinds, such as provisions, ammunition, &c., whilst hardly less important than the transport of troops, requires even more care and forethought, through the longer time taken in loading and unloading, six to ten hours usually for a store train which would carry a day's supply for an army corps of about 30,000 men. Colonel Hazenkampf, however, of the Russian army, calculates that one train would bring up a daily supply for 100,000 men and 17,000 horses. On the other hand, Gen. Wood wrote some years ago, that a railway with five trains of 60 wagons each could secure the maintenance of (only) 300,000 men, and 60,000 horses. And in the *Aide Mémoire* it is stated that six or seven trains a day are required to furnish provisions and forage for a force of 100,000 men. Among such conflicting statements it is difficult to decide which is to be accepted.—(*c*).

*Number of Horses to a Wagon.*

In a goods-wagon (16′ × 8′ 6″ external dimensions) eight horses, or for a short distance nine, can be carried transversely, (see *Plate* V, "Military Use of Railways in India," vol. ii., *Occasional Papers*), but it is not easy to feed or water them and there is difficulty in finding space for their attendants.

If placed with their heads inwards, six to eight horses can be packed in a truck of the same dimensions, and there is space in the centre for the saddles and three men.—(*b*).

*Number of Men to a Carriage.*

A second or third class carriage holds from 24 to 32 men; but if these vehicles are not obtainable, ordinary goods-wagons are easily convertible for the purpose.

An ordinary wagon without any fittings will hold 20 men with their packs and two bell tents, the men sitting on the former.

A battalion of infantry takes (complete with its horses and wagons) from 60 to 70 vehicles, or two to three trains, and is loaded and unloaded in from a quarter to half an hour.—(*b*).

*Special Sidings for Artillery.*

Special sidings, platforms, &c., are desirable, if not absolutely necessary, for the rapid movements by rail of artillery, cavalry, and military stores.

Short sidings for one or two trains are much more convenient than long ones, but for the same amount of accommodation entail greater labour in laying extra points and crossings. A good arrangement is only to have one set of points on the main line leading to a branch one, and from the latter to make the requisite number of sidings. Platforms are best made of railway materials, but, if necessary, can be constructed of earth. Sheds should be provided where troops are to have their meals; good water is essential;* also, means for cooking food, especially for the sick and wounded.—(*b*).

NOTE BY THE LATE COLONEL R. HOME.—"This question of short as against long sidings is really one of long as against short trains. For military traffic long trains are far superior. Putting aside the question of economising traction power, it is very desirable in the case of military trains to preserve tactical and administrative units in railway journeys, that is in separate trains. The maximum train in Germany is 120 axles or 60 carriages. The position of points, which are placed for every day traffic, are often anything but suited for military traffic. Similarly with sidings, and on the number and length of sidings mainly depends the power of the line for the conveyance of troops."

*Water Bottles to be Filled.*

Troops should start with water bottles filled; if cooked rations are issued, recruits and young soldiers should be cautioned against wasting them.—(*a*).

SECTION 3. THE DISEMBARKATION.

*Importance of Space at Disembarkation Stations.*

Besides the selection of a point of departure, the point of arrival must be attended to with equal care. As a vessel cannot be more than full, so a station can only hold just so many trucks and carriages, and until these are emptied the arrival of others only adds to the confusion. This consideration attains its highest importance when dealing with movements of *concentration*. In the choice of stations, whether for departure, main halts, arrival, or depôts, great attention should be paid to the amount of sidings available, and the power of increasing them if required. As a rule, in England, both our sidings and platforms are short, except in stations dealing with large 'excursion' traffic, or in some parts of the coalfields where large mineral trains are common.—(*a*).

*Arrival Station to be kept Clear.*

It is impossible to lay too much stress on the absolute necessity of keeping arrival stations clear of troops, baggage, and stores, more especially as while departure stations are more likely from their situa-

* A number of buckets should be provided for watering horses in the wagons.

tion to be well provided with platforms, &c., arrival stations may not be of equal size.

General McCallum, in his report on the United States military railroads, quotes an order on this point:—

"Commanding officers of troops along the United States' military railroads will give all facilities to the officers of the road and quartermasters for unloading cars so as to prevent delay. On arrival at depôts, whether by day or night, the cars will be instantly unloaded, and working parties will always be in readiness for that duty, and sufficient to unload the whole train at once."

The German regulations lay down that troops are not to remain in towns which are departure or arrival stations; they are only to go to the station and embark; when disembarked to march away at once.—(*a*).

*On Confusion at Arrival Stations, &c., War of* 1870-1.

In addition to troops leaving a station at once, stores, of whatever kind, should be taken away on arrival. In the war of 1870-1 there was a marked inclination on the part of the *Intendance* on both sides to let stores remain in their trucks; it was one of the worst faults committed by the French, and only prevented on the German side by the vigilance of the Route-station Commandants.

As a result the Lyons Railway Company had at the end of the war 7,500 loaded trucks standing on the line.

Nothing can excuse a want of attention to this point, which is, perhaps, the most important that can arise in military railway transport. Accumulations of unloaded wagons are not only a source of confusion by their presence, but also are an indication of a corresponding want of transport at some other place; the block they produce at one place may mean stagnation everywhere else. In the case of troops no excuses should be entertained, such as want of shelter in inclement weather, ignorance of destination, &c.; they cannot be more useless or of more harm than in the trains.—(*a*).

Jacqmin mentions several Officers, among them a General, who refused to let their men disembark at night, *parce qu' ils seraient mieux dans les wagons, que dans la niège*, perfectly true, no doubt, but hardly to the point.—(*c*).

*Importance attached by the Germans to keeping Stations Clear.*

A paper of instructions found in a French station after the war of 1870-1 throws a light upon the importance attached by the German authorities to keeping stations clear.

All trains should be at once unloaded on arrival, and sent away at once, when empty, to allow others to come in. This is one of the essential conditions of regular working, and its neglect has been the chief cause of the irregularities, interruptions, and accumulations which have arisen on the railway. The most serious delays, even the suppression of entire trains, have often arisen from troops not being in their places at the right time; not embarked quick enough; stopped too long at station. Station masters are to see that all trains start to the moment: in this they will be assisted by Route-station and Railway-line Commandants, one of whom, or his assistant, should always be in the station when trains arrive or leave.

Everything must give way to the regular despatch of trains; no excuse of men not having had time for their meals, &c., can be listened to.—(*a*).

*Skidding for Disembarking Horses.*

In order to secure the power of unloading cavalry and artillery trains, even where there is no platform, the Austrian regulations lay down that each such train is to contain a wagon for skidding planks, &c., to form temporary ramps and platform.—(*a*).

### Section 4. The Rate of Traffic.

*Number of Trains Required.*

According to the rules laid down in the "Field Exercise," the following trains are required for

| | | | | | |
|---|---|---|---|---|---|
| 1 battalion infantry ... | 2 trains of | 28 | carriages each. | | |
| 1 squadron cavalry ... | 1 ,, | 34 | ,, | and trucks. | |
| 1 field battery ... ... | 2 ,, | 24 | ,, | ,, | |
| 1 troop, R.H.A. ... ... | 2 ,, | 27 | ,, | ,, | |

Abroad the military trains are heavier and the speed less.

In Germany a military train is laid down to carry as a rule,

1 battalion of 1000 men; or 1 squadron of 150 horses; or 1 battery of six guns.

The movement of the 8th Prussian Army Corps from Aix-la-Chapelle to Halle, between May 27th and June 3rd, 1866, consisting of 926 officers, 30,747 men, 8,576 horses, 95 carts, and 3,215 wagons, was effected by 12 trains each day, containing—

| | | | | |
|---|---|---|---|---|
| Infantry train ... | 1060 men, | 30 officers, | 36 horses, | 4 carriages. |
| Cavalry ... ... | 160 ,, | 6 ,, | 200 ,, | 3 ,, |
| Field artillery ... | 140 ,, | 3 ,, | 120 ,, | 15 ,, |
| Horse artillery ... | 157 ,, | 4 ,, | 208 ,, | 15 ,, |
| Stores ... ... | 130 ,, | 1 ,, | 120 ,, | 15 ,, |

As at present laid down, an English army corps, whose fighting strength is 27,000 sabres and bayonets, and 90 guns, requires for its conveyance 135 trains of about 34 carriages each, giving one carriage to every six sabres and bayonets, armed, equipped, and provided with their due proportion of guns, tools, pontoons, telegraph, hospital, &c.—(*a*).

*Number of Trains per Day in Germany.*

In the Prussian regulations for 1867, eight trains on a single, and 12 on a double line is laid down for ordinary military transports. The trains are despatched rather quicker than they need be, to allow of a day being gained every now and then to make up for irregularities; this is a good plan, but we think more trains might be sent, as they are sure to be required in time of war, and, indeed, are always used. For example, the French in their last war employed on an average 18 to 24 trains a day for transporting troops, and in special cases many more. After the defeat at Sedan as many as 135 trains, chiefly full of fugitives, were sent off in four days, and in evacuating Le Mans Station just before the German occupation, 25 trains were despatched in seven hours, besides seven others which were close to the station, but not unloaded (and this amid the greatest difficulties). Colonel Hamley is of opinion that most English lines could supply *eight trains an hour* for a short transport, which he considers the utmost limit consistent with safety. Passing to the other extreme, on the single Russian lines, Colonel Hazenkampf thinks that only 10 military trains could be sent in 24 hours even if the ordinary traffic were entirely stopped.—(*c*).

*Working a Single Line.*

We should mention here a point sometimes discussed (as by Costa de Serda), whether on single lines the transport should be *continuous* or *by echelon*; in the former the first train returns to the starting point by the time the last train leaves it; thus, no break occurs; in the latter all the trains are despatched as quickly as possible one after another; the transport is then stopped whilst all the trains return, and then resume as before. By this method the chance of accidents is lessened, but in point of time the other is far preferable, and would therefore be chosen, unless (1) the rolling stock be very abundant, or (2) the loop lines where trains could cross very few, or (3) a portion of the transport be wanted in a great hurry.—(*c*).

*Size of Trains.*

We agree with the Austrians in thinking it undesirable to fix an absolute limit to the number of vehicles which one train can carry in time of war. In France this was laid down at 40, as a measure of safety, but in the last war 60, and even 75, were taken with no accident. The Germans decided on 60 to 100 axles, perhaps a better way of estimating the length of trains, as carriages vary much. An axle, the Germans reckon, can carry about 16 men equipped, or four horses with a groom: and a train of 60 to 100 axles either 1,000 infantry, or 150 horses, or six guns, or three-quarters of an ammunition column. Similarly, the Russian trains take 50 to 100 axles, according to the inclines on the line (Colonel Kazanski).—(*c*).

*Return of Empties.*

According to the German regulations carriages may be expected to return—

| | | | |
|---|---|---|---|
| After a journey of 300 | kilomètres | ... ... | the 3rd day. |
| " | 300 to 600 " | ... ... | " 4th " |
| " | 600 to 900 " | ... ... | " 5th " |

And as the speed of German military trains is laid down to be about 22 to 26 *kilomètres* per hour, and of English trains about 25 *miles* per hour, the above figures will stand for our use, reading miles for kilometres.—(*a*).

*Rests on Journey.*

In long troop-transports there should be regular stoppages for refreshment and rest; they should be long enough to be a *real* rest, but not too frequent (say for two hours every eight hours). The 'resting' stations should, of course, be chosen beforehand, and the necessary arrangements made. In addition a short rest of ten minutes may be allowed every two or three hours when the men in charge of the horses, baggage, &c., would be relieved, and the engines watered.—(*c*).

*Rate of Travelling.*

The speed of military trains may be assumed as not likely to exceed 25 miles an hour, including short halts for water, &c., every two or three hours.—(*a*).

*Refreshments.*

A halt of about one to two hours should be made at intervals of nine to ten hours to feed horses and men. These halts should be made at selected stations, which should be provided with large accommodation for refreshment purposes, means of watering horses, extra latrines, and shelter for sick not able to go on.

During the Prussian occupation of France in 1870-1, the goods-stations at Epernay and other places were converted into enormous dining rooms for the troops; tables on trestles were placed on the platforms, and cauldrons for cooking established outside.

At Châlons the engine shed was used for the same purpose; the cleaning pits were planked over and tables placed throughout the shed, which was warmed by stoves and lighted with railway lamps. At the entrance were tanks of hot and cold water for ablution. The cooking was done by steam supplied by a locomotive fixed in the kitchen.

Jacqmin also instances the employment of waste steam from a locomotive to heat coffee, &c.

When troops arrived each man took his mess tin, got his portion of soup, and afterwards took his ration of meat back with him into the train, while others went to the dining room.—(*a*).

*Carriage of Food in India.*

The Great Indian Peninsular Railway during the recent Madras famine, when every nerve was strained to pour food into the famine districts, conveyed as much as 2000 tons per day in addition to passenger traffic, and this large quantity may be assumed as the maximum almost which a single line can transport over long distances with stations far apart, even with very special arrangements. The ordinary working capacity of that railway does not amount to half this weight.—(*b*).

*Food required for an Army.*

From a careful commissariat return of the weights of the rations of different arms of the service, it has been calculated that to supply them with food, forage, and fuel for cooking each day, the following carriage will be required:—

Battalion of infantry—

$\left.\begin{array}{r}\text{1097 men}\\ \text{65 horses}\end{array}\right\}$ 52 cwt.

Regiment of cavalry—

$\left.\begin{array}{r}\text{653 men}\\ \text{615 horses}\end{array}\right\}$ 133 cwt.

Battery horse artillery—

$\left.\begin{array}{r}\text{179 men}\\ \text{179 horses}\end{array}\right\}$ 38 cwt.

Battery field artillery—

$\left.\begin{array}{r}\text{198 men}\\ \text{154 horses}\end{array}\right\}$ 35 cwt.

Company of engineers—

186 men } 7 cwt.

It may be roughly assumed that to feed 1000 men, including the carriage either of live stock or tins of meat, and the provision of fuel, carriage for two tons, or half a railway wagon, will be necessary.

A thousand horses will need daily ten tons of forage, which, even when compressed, is bulky, and will take five wagons to carry.—(*b*).

*Supply of Paris in* 1870.

As an example of the wants of a great city, Jacqmin cites Paris as requiring daily for a population of 2,000,000 inhabitants 7,000 tons of various provisions, fuel, &c., or about 1,000 truck loads, say 20 trains.—(*a*).

*Siege and Store Traffic.*

In a military railway rapidity of construction is the most important consideration; the heaviest weights to be carried are siege guns, or possibly a 7-inch gun, weighing 95 cwt., consequently the greatest weight upon each wheel, if the gun be carried in an ordinary four wheeled wagon, will be under two tons, and as stated previously the gross weight of the provisions for an army in the field will not exceed two tons each day per 1000 men, and ten tons per 1000 horses. In case of a siege the amount of material to be transported for a short time will tax all the resources of the line to the utmost; but a light line with light locomotives and rolling stock will answer the purpose, and best repay in rapidity of construction its want of carrying power.—(*b*).

## Section 5. Ambulances.

*Requirements.*

The transport of sick and wounded forms a very important subdivision of railway transport, and few of the ordinary types of railway vehicle are well adapted to its special requirements.

The principal conditions are easy travelling and absence of jolting; free communication throughout the train to allow of medical attendance while *en route*; arrangements to permit the patients to lie down, and convenience for cooking.—(*a*).

*Russian Experiments.*

Dr. Esmarch, surgeon, of Kiel, proposed in 1867, wagons with doors at the end, so as to permit of communication throughout the train; the patients to be brought from the ambulance or field on stretchers, which were to be hung on india-rubber rings or supported by springs. Carriages thus constructed were experimented upon, and proved satisfactory.

In the hospital train should be carriages for the surgeons, surgery, stores and cooking arrangements, all in communication.

The Prussian Minister of Commerce had 200 wagons constructed on this system. The stretchers were hung in two tiers, with a centre passage.—(*a*).

*South German Ambulance.*

In Wurtemburg the ambulance train was of similar nature, as were those of Bavaria, the latter having in addition carriages of the American type, which were well adapted for slightly wounded and sick.—(*a*).

*English Experiments.*

In England experiments have been made as to the best mode of fitting up covered goods-trucks and brake-vans in the manner described, and they would probably be of great service. The difficulty of communication is, however, a decided obstacle, and one almost insuperable from the present construction of our rolling stock. The best carriages we have for this purpose would be the saloon carriages and Pullman cars now in use on the main lines to the north. These might certainly be regarded as the mainstays of any ambulance trains for use at home. Railway companies might also be induced to construct a certain number of carriages and trucks with end doors; the additional expense would be but trifling, and the advantage great.

Large third class carriages might also be so constructed as to allow of their ordinary seats being easily removed, so as to afford room for hanging stretchers, and as long six-wheeled carriages are coming more and more into use, they would be found very suitable for sick and wounded transport.—(*a*).

*Conversion of Ordinary Carriages.*

Carriages and ordinary goods-wagons are so easily convertible into ambulance wagons on a few days notice that it seems unnecessary to provide special carriages for this purpose.—(*b*).

While it is necessary to provide special ambulance carriages for all serious cases, it is equally necessary, perhaps more so, to be able to fit up ordinary trains to convey the sick and wounded when others are not available. * * * * Whenever possible, and every effort should be made to make it possible, the patients ought to be placed in the train, and afterwards carried to the hospitals on the same stretchers on which they were brought from the field, or temporary ambulance. Two changes are thus avoided, and the men saved much suffering. The sick should lie longitudinally in the carriage, as the shaking is less, and the most serious cases should be placed near the centre of the train for the same reason. * * * * Ordinary passenger carriages, such as are used on English and most continental lines, are suitable (or can easily be made so) for the transport of such sick patients as do not require a recumbent position (about two-thirds of the total number on an average), but they are not suitable for those who do, because—(1) the doors are too narrow (20 to 24 inches), to admit an ordinary stretcher; (2) the compartments are too narrow to admit of patients lying parallel to the rails; (3) the seats are too narrow to allow of one on each, and hence in each compartment only one stretcher can be carried, and that along the middle, resting on both seats or on the floor. * * * * The above objections also apply to the partially open 2nd and 3rd class carriages now coming into use, though to a less extent, as the low divisions between the compartments facilitate the arrangement of stretchers when once got in, but the narrowness of the doors is as bad as ever. * * * * Lastly, there are various kinds of goods-wagons, horse-boxes, trucks, &c. These when *covered* are more suitable than passenger carriages, having larger doors, often without steps, and ample space inside; also, they are more likely to be at hand during a campaign, as stores, &c., will have to be continually sent to the army, whilst troops only occasionally after the war has once begun.—(c).

*Experience in the American War.*

During the American war we have the first use, on a large scale, of special carriages for the transport of the sick and wounded. We do not mean that they were made for that purpose alone; they were also passenger cars, only so arranged as to be easily made suitable for sick transport. In 1863 several of these were constructed, and as they succeeded remarkably well, and were inexpensive also, many more were afterwards made. In general principle they so nearly resembled the Prussian carriages described later on, that it is only necessary here to mention the chief difference: they were much *longer*, containing 32 litters; the details of lighting, airing, heating, and suspending the stretchers were also somewhat different. The litters used were the ordinary field stretchers, easily fixed in their places within the car; this method proved a great success, and was largely adopted.—(c).

*German Ambulance*, 1870.

But in Europe it was not till after the war of 1866 had conclusively shown that ordinary trains were unsuitable for the conveyance of recumbent patients, that the subject of special ambulance trains received much attention. The Prussian Minister of War then appointed a committee to examine the question, and in the report they drew up, the points chiefly insisted on for patients requiring a recumbent position, were the following:—

(1) The necessity of such carriages as would allow of through communication.

(2) Of either springs under the beds, or else litters suspended from the roof or sides.

(3) Of extra carriages for the doctor, attendants, surgical apparatus, medical stores, cooking utensils, &c.

These principles having been tested and found to hold good, means were taken to enable them to be carried out in practice. All the 4th class carriages of the State railways were ordered to have 'end' doors, with small bridges to be let down joining them together. Having no interior divisions or fittings except a few posts on each side, the only addition needed was a simple method of suspending the field litters from these, which was easily managed by hooks and caoutchouc bands. Each carriage could contain 12 stretchers.

The advantages of such a system are—the carriages, though specially contrived for sick transport, being those in ordinary use, would probably be available in large numbers in actual war; they are well aired and lighted, and not being over crowded there is ample space for the attendants, &c.; they are suitable for other stretchers besides the ordinary field ones, and the caoutchouc bands lessen the jolts due to the train's motion; being loaded from the end the stretchers need not be turned at all in getting in; and last, though not least, there is the freest possible communication from one end of the train to the other, thus doing away with the necessity of frequent halts, lessening the number of attendants needed, and adding much to the convenience of the doctor, and the comfort of the patients. Means were also taken to utilize the goods' vans and horse boxes, but only as supplementary to these carriages. A very similar system was adopted in South Germany, only there fewer alterations were needed, as the carriages had already end doors.

Before long the war of 1870 clearly demonstrated the use of these preparations, the sick transport trains were replete with, if not every, at all events, many comforts, and the highest praise is due to those who made the arrangements originally, and to those who carried them out so successfully in practice. We are surprised, however, that they were not employed sooner in the campaign, if Jacqmin is correct in stating that the first ambulance train (Bavarian) did not start till the 15th September; then eight were sent to the seat of war with about 20 carriages each. We should notice in passing what proved to be a good idea—namely, to allow such of the men who were able to sit up *a little* to do so by turns, while others lay down in their places; thus more men could be carried than if each had to be provided with a separate bed. Later on the first Prussian ambulance train left Berlin for Metz on the 2nd October; it had 14 carriages, able to convey 150 men lying down, which was the usual number for a train, though some from Wurtemburg carried as many as 192.—(c).

### SECTION 6. THE DESTRUCTION OF RAILWAYS IN WAR TIME.

*Examples of Destruction.*

In the American War of Secession upwards of 700 miles of line were totally destroyed and 3,700 miles rendered useless for six months.

In the war of 1866, there was much useless destruction of lines, &c.—such as the total destruction of bridges, when, from the circumstances of the case, the removal of the rails would have been sufficient.

Jacqmin gives a long list of the destruction of lines, bridges, &c., in France during the war of 1870-1; and there is little doubt that a large portion of this was unnecessary:—(a).

*Projects should be Prepared Beforehand.*

All destructions of this kind should be based on information derived from reconnaisances, not merely during war, but carefully made in peace with a view to possible requirements.

An Austrian work entitled "Railways considered from a military point of view," quoted in a work on the same subject by a Prussian officer, and translated into French under the title "*Emploi des Chemins de Fer en temps de Guerre*," gives the following points which should be noted in time of peace, and all information connected with them carefully arranged.

1. System of construction of permanent way: rails, chairs, fastenings.

Gauge and number of lines, whether single or double.

2. Stations: size of and construction—which are best fitted for depôts.

3. Underground works, bridges, &c.,—which are easiest destroyed, and soonest repaired if destroyed? are they prepared beforehand for destruction?

4. Embankments: Size, how made, slope, culverts if any, and their size.

5. Cuttings: Length and depth, slopes, nature of ground, much or little water, danger of land slips.

6. Tunnels: Their dimensions and construction—are they lined or cut in rock? what are the cuttings at the ends? can they be blocked?

7. Large bridges and viaducts: System of construction—span of arches—are the piers mined?

8. Snow galleries: how made—size.

9. Ferries: by steamer or how? are there hydraulic or other lifts?

10. Where can men, tools, stores, and materials be obtained, and to what extent?

Experience has shewn that it is not only necessary to have, in time of peace, designs of the principal bridges, &c., but timber for their repairs should be made ready beforehand. The repair of the bridge of Riesa, burnt by the Saxons, June 15th, 1866, was delayed by this being the *only bridge* of which designs had *not been obtained*, the Saxons having watched it with great care. On June 16th, 1866, the 2nd Railway Division of the Prussian Army, under the working director of the Lower Silesian Section, commenced repairs, and on the 18th trains crossed the bridge. The work of repair was assisted by large stores of wood found in Riesa.—(*a*).

*Best Points to Attack.*

The best points of attack are naturally those to which the enemy attaches most importance, such as main lines of communication and concentration—lines uniting fortresses, large junctions, whose destruction disables two or three lines—lines on each side of large stations, which, if cut, will lock up and render useless a large quantity of rolling stock.—(*a*).

*All Arrangements should be Complete.*

Jacqmin mentions that the tunnels in the Vosges mountains were *mined*, but the mines were not *charged*, and the Germans, to their extreme delight, occupied the line before the necessary order for destruction arrived.—(*a*).

*Description of Troops Required.*

The manner in which an attack on hostile railways is executed will depend upon whether the condition admits of a total and deliberate, or a hasty and incomplete demolition.

As a rule cavalry may be taken as the arm most adapted for this kind of warfare; but, nevertheless, more is required than the ordinary cavalry soldier can do. What is wanted is a man combining the artificer and the horseman, as the old dragoon was indifferently horse or foot soldier. For attacks on hostile lines rapidity of movement is essential. Cavalry, horse artillery, mounted engineers, artificers in light wagons must be the troops for these operations. In the great cavalry raids in the war of Secession in America hundreds of miles were covered by such rapidly moving bodies, whose presence was only known by the destruction they left behind them.—(*a*).

*Modes of Crippling a Railway.*

The troops for this service should be equipped with the tools necessary for cutting down telegraph poles, unscrewing fish-plates, tearing off chairs, gun cotton for breaking rails, &c.

If they succeed in surprising a badly guarded station some extensive destruction can be attempted—points and crossings destroyed, water tanks deprived of their shoots, gear, &c., engines disabled. The proper supply of water being an essential to a locomotive, any damage done in this respect is of the greatest importance. Rolling stock should be burnt if it cannot be removed. The destruction of permanent works such as bridges, &c., is a serious affair and requires more precautions; as they may be usually expected to be well defended, a covering party should accompany the troops engaged in the demolition.

It is of no great use to destroy *little* bridges and culverts; the gaps are easily filled or bridged over.

*In destroying home lines*, those portions should be destroyed which will most delay the enemy by their absence.

No destruction can be considered of importance unless the material is removed or rendered useless. In the American war of 1860, sleepers were laid in piles like crib work with the rails placed on the top. The piles were fired by petroleum, and the heat caused the rails to bend and become useless. Points and crossings should always be removed, they are difficult to replace.

A very serious block in a railway may be obtained by blowing in the sides of a cutting; but this can only be successful when done on a large scale, and in a situation where it would be difficult to get at and remove the débris.—(*a*).

*Destruction of Tunnels.*

In a hilly country the destruction of a tunnel may place an absolute bar to the employment of the railways running through it.

The tunnel of Nanteuil in the Vosges mountains was blocked during the war of 1870-1 by the French at the western end by the explosion of six mines placed three on each side: one pair 4 metres from the end, the next 12, and the third pair 20 metres. Each mine was loaded with 200 kilogrammes of powder. The arch side walls &c., were destroyed for a length of 25 metres, bringing down a mass of about 4000 cubic metres of sand. The Germans drove a gallery into the fallen mass, but wet weather produced fresh slips, and destroyed their work; they were eventually obliged to turn the obstacle thus created by the construction of a branch line which did good service during and after the campaign.—(*a*).

*Hasty Injury of Rails.*

Major General Sir G. Wolseley gives a number of useful hints on the subject of destruction of railways and rolling stock.

One of the most ingenious was employed in the American war for detaching rails. It merely consists of an iron claw with a hole for a lever. The claw is placed under the rail and the lever inserted and pulled over when the rail is torn from its fastenings.

He also describes a wholesale method of removing rails and sleepers. A large body of men are formed along an embankment, the ballast removed so as to uncover the rails, and the end rails unfished: at a given signal the whole of the rail on one side is lifted up, sleepers and all, and turned over so as to fall down the embankment.

He also gives hints for the total destruction or partial disablement of locomotives or carriages. Such as firing a shot through the boiler, or removing some of the moving parts, pumps, brasses and bolts.—(*a*).

During the American War much experience was gained in this work, and long wooden levers with U shaped iron claws were used for tearing the rails from the sleepers and twisting them so as to render them useless without being re-rolled. A line is rapidly torn up in this way,* 450 men being able to destroy a mile of single line in an hour's time. Curves should be selected for the purpose, as they are more difficult to relay than pieces of straight line. If there are wooden bridges on the line they should be burnt, and if any oil or petroleum is obtainable it should be poured on them to increase the flames.—(*b*).

*Destruction should be Complete.*

One point is worth remark in connection with the destruction of a line; it is better to destroy 100 yards completely than to partially destroy twice the length; so, if time is short, do what you can thoroughly.—(*a*).

* Provided the line is laid with a single flanged rail, spiked to the sleepers with ordinary dog spikes.

*Detail of Party for Destruction.*

The following is a detail of the division of a party employed in the rapid destruction of 200 yards of line: 100 yards at a time.

The party to consist of 100 men. They should be stationed at first a yard apart to remove the ballast. That done, they should be divided into two sections, one of 25, one of 75 men.

1st Section:—10 unfish the joints.
12 draw spikes or dogs.
3 carry tools.

2nd Section:—60 carry away rails, when ready, to trucks in waiting to remove them.
15 remove small stores.

Then the full party of 100 remove the sleepers.

The tools and materials required for such a party would be:—

75 shovels.
50 picks.
10 spanners.
20 crowbars.
20 iron shod levers.
100 carrying bars, for rails.
5 sledge hammers.
cold chisels, hand hammers, &c.
16 open trucks, for materials.
1 ,, for tools.
4 ,, for men.—(*a*).

*Destruction of Bridges.*

The most effective way of crippling a line is by the destruction of a large bridge, by blowing down one of the girders or arches, and, if such a work do not exist, the defenders can only hope to retard, more or less, the use of the railway by the enemy.*—(*b*).

*Destruction of Permanent Way.*

The destruction of portions of the permanent way, after the rolling stock has been removed, is almost always resorted to as the easiest and most rapid method of temporarily disabling a railway.

If the rail is a double-headed one with cast iron chairs, the keys should be removed, and the outer claw of each chair smashed with

* Numerous instances might be noted of the destruction of railway bridges for the purpose of rendering the lines useless to the enemy. The demolition of the one over the Elbe, near Lobkowitz, consisting of four spans of 125 feet each, by the Austrians, in 1866, rendered the line of railway which led over it impassable for the Prussians. The destruction of the bridge at Fontenoy-sur-Moselle, between Nancy and Toul (seven large masonry arches), would have made a very serious break in the communications of the Germans over the principal line between Paris and Germany, but for the mistake made by the French in blowing up two arches at the side of the bridge instead of in the middle, and the Germans were able to fill them in with stones and earth, and restore communication in 17 days (January, 1871).

heavy sledge hammers; if time permits the rails should have the fish plates taken off and be removed, but this is a work of considerable labour.

A line composed of single flanged rails, spiked to wooden sleepers, is best destroyed, when the sleepers are dry and will burn readily, as follows: The fish plates should first be taken off, the ballasting loosened, and the rails with the sleepers attached to them lifted up and thrown over; a fire being made of the sleepers and fencing, the rails are heated over it (in the centre); when red hot they are easily bent and twisted by hand so that they cannot be straightened without being rolled again. Hasty demolitions of permanent way are best made by the use of guncotton discs laid on the rails and exploded by detonating fuzes. If they do not break the rails they will render them unserviceable by twisting and bending them. With the aid of a small lorry and a few men miles of line can rapidly be crippled.

The labour in removing the permanent way of a railway is so great that it cannot be undertaken except for short distances; frequent and small interruptions are best at distances which render it difficult for the enemy to bring up materials for their repair by hand.—(*b*).

*Destruction of Rolling Stock.*

If rolling stock has to be abandoned one wheel on each axle should be smashed with a heavy hammer to prevent the vehicle being used, and if this cannot be done it might be burnt.*

The working parts of the engines, including their safety valves, should be removed.†

Points and crossings should be smashed or taken away to prevent the sidings being of use to the enemy.—(*b*).

*Example of Destruction—American War.*

"Guerillas and raiding parties were more or less successful in destroying portions of track during the whole time we held this line; but the crowning effort was made by the enemy in October, 1864, when Hood, getting to Sherman's rear, threw his whole army on the road (first at Big Shanty, and afterwards north of Resaca) and destroyed in the aggregate $35\frac{1}{2}$ miles of track and 144 lineal feet

* The object being to prevent the railway being of use to the enemy, and not to destroy the property of the railway company, as little damage should be caused as is actually necessitated to thoroughly accomplish the object sought.

† The working parts are pumps, safety valves, mud plugs to boiler, eccentric rods, slide valves, &c. If an engine is to be destroyed a round shot should be fired into it, or a large fire lighted in the boiler grate, and no water put in the boiler, or it may be blown up by screwing down the safety valves and getting up steam, or by the explosion of a charge of powder.

of bridges, killing and capturing a large number of our men."—*General McCallum's Report.*—(*a*).

### Section 7. Reconstruction of Railways in War Time.

*Example of a Railway Corps in the American War.*

On the 11th February, 1862, a Director-General of Railways was appointed by the Federals, and soon after McCullum was nominated to the post with *absolute* power, both over the railways themselves and over the manufacturers of carriages and engines. The interests of private companies were sacrificed, we think justly, for the public good.* McCullum immediately formed a corps of railway constructors, not exactly a military corps, yet under a severe military discipline; commencing with 400 men it increased to 10,000. "The design of this corps was to combine a body of skilled workmen in each department of railroad construction and repairs under competent engineers, supplied with abundant materials, tools, mechanical appliances, and transportation." It was composed of the bravest and most active railway workmen, under experienced railway engineers. As an example of its organization, we will reproduce that of Sherman's corps, in the military division of the Mississippi. One chief engineer (civil) with 6 divisional engineers under him; each of these had two chief inspectors commanding subdivisions, one composed of carpenters and constructors, the other of platelayers. Each subdivision had 4 to 10 sections, numbering 40—100 men each, commanded by an inspector, who had two sub-inspectors under him.

This Mississippi division had on the 31st October, 1864, 4,623 men, viz., 2,781 carpenters and constructors, and 1,842 platelayers, each with appropriate tools. This corps was employed only for *destroying* and *repairing* the lines; for *working* them there was another corps, still more numerous (9,681 men). The cost of the two during the last 6 months of 1864 was 4,200,000 dols.

It is not intended here to enter into the numerous, almost innumerable, instances of their destroying and repairing railways; that would be a separate subject by itself, so we only quote one example, the celebrated rebuilding of the Chattahochee bridge. It was 780 feet long, 92 feet high, and was rebuilt by the construction

* How far to indemnify railway companies for losses in war is a doubtful question. They certainly ought to be indemnified in part, considering the enormous expenses the Government transports must have caused them (besides the actual fares). But again it seems unjust to indemnify them entirely, as then they would probably be the only companies in the whole country which had not suffered from the war. A mean coures must be taken, the difficulty is to fix the line.

corps in $4\frac{1}{2}$ days!* Some idea of the extent to which railway warfare was carried, may be gained from the fact, that of the 6,330 wagons, and 419 engines employed, only 500 of the former, and 103 of the latter remained uninjured; and at one time the Northerners employed over 24,000 men on their railways. The cost was naturally large, amounting during the war to 30,000,000 dols., but they cared little for expense if they got a proportionate return, which they certainly did. "Their railway organization became at length, *i.e.*, after about three years of war, so good as to enable the Federals to supply General Sherman's army of about 100,000 *men*, (60,000 *horses*) with supplies from about 860 *miles distance*, by *one single line of track railroad, located almost the entire distance through the country of an active and vindictive enemy*."—(*c*).

*Examples of a Railway Corps in Germany.*

The Germans in the war of 1870-71 had their *Feld Eisenbahn Abtheilungen* as before, altogether 5 companies of about 200 men each, but after the experience of the war it was considered desirable to consolidate these into one body, so a *Railway Battalion* was formed, by Royal Order, May 19th, 1871. It was composed of a staff, 4 companies (100 men each) and a depôt. "Upon mobilization each company is augmented into two *construction* companies and one *traffic* company, making an establishment on a war footing of eight construction and four traffic companies. Also a *reserve* division consisting of a staff, two companies, and a section of tradesmen. Each of the construction companies has a train of 5 wagons for the transport of tools and materials."† This battalion was fully exercised in peace time, both on the State, and on private railways. "During the first year of its existence, 1872, the battalion constructed 100 miles of permanent way; two termini, with their points and crossings; one roadside station; enlarged four termini; restored two dykes destroyed by inundations, and a railway bridge at Rykgraben near Greifswald." The total cost of the organizing of the railway battalion in 1872, including the purchase of land for a station and practice ground, and the cost of building a barrack, amounted to £140,880. This railway battalion was a decided success, but still the Germans were not satisfied, so early in 1876 a *Railway Regiment* was formed of two such battalions, the companies augmented in

* Numerous other examples are given in "Puissance Militaire des États Unis d' Amerique."

† A full account of the equipment, &c., of this corps is given in Jacquin, pp. 339 to 342.

war time as before, and of course constantly practiced in peace time on the different lines.*—(c).

*Examples of Railway Corps in other Countries.*

In *Austria*, some years ago, special Field Railway Companies were formed, each consisting of a civil section (engineers and artificers) and a military section (pioneers and sappers). To ascertain the probable strength of the former the railway companies had to send to the War Ministry, twice a year, a report, stating the number of men they were prepared to hand over to the railway department in case of mobilization, with their general qualifications.

In *Italy* each of the two engineer regiments has two railway companies. In time of war the whole four would join the army in the field. They are intended chiefly for destroying and repairing railways, within the zone of active operations. Moreover, on all lines of railways, there are Military Railway Commissioners, consisting of officers of high rank of all arms, and intended to act as a medium between the War Ministry and the railway companies in all that concerns military transports. The instruction of officers in railway management is also well attended to; every year over 50 of them commence a railway course; it consists of two parts—(1) preparatory, lasting about three weeks; (2) practical—actually supervising the traffic at the stations, lasting a somewhat longer period.

In *Russia*, as early as 1871, military railway detachments had been organized. They were to be formed on the mobilization of the army, and each to consist of a technical director (with staff) and a division of workmen, either civil, or else fatigue parties from the troops. During peace 1000 men (fourth sappers) received instruction on the existing lines. In 1873 new and revised regulations were issued for military transports. These were to be under the charge of special officers (similar to the German Line and Route Commissions), and fulfilling the same duties. In November, 1876, a *railway battalion* was formed at Moscow. It had two construction, and two traffic companies, comprising altogether 24 officers and 990 men (combatants). All of these had before been instructed in the railway detachments.—(c).

* The peace footing organisation is (U.S.J., xx., p. 750, by Lieut. Fewson, R.E.) 4 field officers, of whom 1 commands the regiment, 2 the battalion, and 1 is without special command, 8 captains, 8 lieutenants, 27 second lieutenants, 2 surgeons, and 2 assistant surgeons, 3 paymasters and 3 temporary paymasters (awaiting commission), 2 armourers, 1 drum-major, 9 drummers and fifers, 8 hospital assistants, 24 tradesmen, 8 sergeant-majors, 8 vice sergeant-majors, 32 sergeants, 103 under officers, 98 lance-corporals, and 700 men.

of the break at Big Shanty and this gap of ten miles was closed, and the force ready to move to the great break of twenty-five miles in length north of Resaca, as soon as the enemy had left it. The destruction by Hood's army of our depôts of supplies compelled us to cut nearly all the cross-ties required to relay this track, and to send a distance for rails. The cross-ties were cut near the line of the road, and many of them carried by hand to the track, as the trains to be furnished for hauling them did not get to the work until it was nearly completed. The rails used on the southern end of the break had to be taken up and brought from the railroads south of Atlanta, and those from the northern end were mostly brought from Nashville, nearly two hundred miles distant.

"Notwithstanding all the disadvantages under which the labour was performed the twenty-five miles of track were laid and the trains were running over it in seven and a half days from the time the work was commenced.

"The economy so commendable and essential upon civil railroads was compelled to give way to the lavish expenditure of war; and the question to be answered was not 'How much will it cost?' but rather 'Can it be done at all at any cost?'"—*General McCallum's Report.*—(*a*).

*Mode of Crossing a Gap.*

A very steep straight gradient down one of the banks of a river, and an equally steep one up the other side, can often be made and taken by the train at a rush, the momentum gained by the descent being utilised to overcome the resistance of the ascent,* or wagons can be hauled up a steep slope by a winch or other mechanical means. Wire suspension bridges can be rapidly made, which, when properly stayed, are rigid enough for the passage of loaded wagons. —(*b*).

## Section 8.—Attack and Defence of Railways in War.

*Defence of Lines in General.*

1. The concentration of rolling stock at the most convenient places.

2. The division of the work to be done over different lines; the arrangement of the rate of travelling, stoppages, intervals between trains, &c.

3. The erection of sidings, platforms, and sheds, &c., at places

* This is a common expedient on Indian railways when the bridges get carried away by high floods, and the beds are left dry a few hours afterwards. Slopes as steep as 1 in 10 are used.

where troops and stores will be embarked and disembarked; sheds for the refreshment of troops at halting places, &c.

4. The arrangements for the demolition of the lines, if necessary to abandon them to the enemy, and the defence of important works and stations.

5. The instruction of the troops and railway officials in loading and unloading horses, military stores, guns, fitting up ambulances, &c.—(*b*).

*Employment of Cavalry.*

Rapidity is essential to success, so cavalry will be almost always employed in attacks on railways.* They may either carry with them small bags of powder and a few tools, or else be accompanied by workmen for the special purpose. The German cavalry have 1 lb. dynamite cartridges for blowing up the joints of rails. With their usual foresight the Germans have also established at the Hanover Cavalry School special fortnightly courses for practicing that arm in destroying railways.—(*c*).

*Examples of Defence of Lines—Germany—America.*

The Germans, we read, employed as many as 100,000 men to defend the railways in France, and large as this number seems, we can quite believe it was not too large, considering they worked 3,800 kilomètres.† This would give an average of 42 men to the mile When in one's own country, of course a fewer number would suffice yet we must remember that an enemy's cavalry will venture a long way to cut its opponent's communications (as Stuart's, for example, in the American war), and therefore, the lines forming these ought to be carefully watched in any case. In 1864, General Sherman guarded his railway communications most effectively all the way from Nashville to Atalanta, and this against numerous attacks by a powerful enemy, which shows that although the defence of railways may be difficult, it is by no means impossible.‡ The Prussians neglected similar precautions in 1866, or at least did not make them so effectual, the result being that the Austrian Captain Vivenot, with only 30 to 40 men, was able to cut their railways in rear, causing numerous delays.—(*c*).

*Forts for Special Junctions.*

There may be points on a railway which it is desirable to de-

* The number of horses required for large undertakings of this kind is immense. In 1863, the army of the Potomac alone had 35,078 dead or useless.

† On some lines even every signal box had to be occupied by a detachment of troops, and yet the Franc-tireurs were able to cause interruptions.

‡ Moreover, in 1861-65, McCallum worked successfully over 1,930 kilomètres in an enemy's country under similar difficulties.

fend, either from the ease with which it can be done (defiles), or else from the importance of the works they cover (bridges, tunnels, railways, arsenals), or again from the number of lines which they command (junctions), and yet no fortress may be there; this would be especially the case in England where fortresses are scarce. At such places, which, if well chosen, need be very few, we would recommend the erection of small independent forts. Built in time of peace, and wholly for military purposes, they would have small garrisons, ample bomb proof cover, almost inexhaustible provisions, and no civil population. They would thus be well able to stand a lenthened siege. In choosing their position the following objects should be had in view:—

1. To prevent the enemy capturing them by assault, blockade, or otherwise; and if defending any particular works, to prevent *his* destroying it, though having the means of doing it oneself if needful.

2. To *completely* command the line, so as to prevent its being used even with the help of large traverses. (We mean it would not be enough to command, sideways, a portion of the line, unless that were a bridge on which the enemy could not build a traverse).

3. To oblige the enemy to make as long and as difficult detours as possible, to connect the portion of the line out of range of the forts. The nature of the country must of course be considered, whether it is hard or marshy, whether bridges or tunnels would be necessary, whether wood is plentiful, whether there are good roads to bring up the materials by, and, finally, whether the ground admits of rapid sorties being made (by cavalry?) to destroy the enemy's line, especially those portions which took him longest to make.

4. Lastly, should a capitulation be necessary, to be able to create as great an obstacle as possible on the line. This is another reason for being near some important bridge or tunnel; even at a distance its destruction might, perhaps, be effected by having wires leading to a previously prepared mine; the only difficulty is to prevent their discovery.*—(*c*).

*Examples.*

We have not met with any practical example of such a fort as above described, perhaps Bitsche in the Franco-German war was

* Such forts have been proposed by Jacqmin, p. 298; Formanoir, 1868-70, and other writers. We would wish to be able to enter more into detail as regards their size and cost, but it appears impossible, as it must depend entirely upon where they are placed, and for what special object.

the nearest; it completely blocked up the line from Sarreguemines to Niederbroun, and thereby, as Jacqmin says (p. 247), rendered great service to the French. The Prussians, years ago, erected a small defensive work at Kottbus, to protect the railway bridge over the Spree there, but it does not seem intended to resist a long attack. However, one that is being built at Hanover, between Neuss and Dusseldorf (it is probably finished now), represents exactly what we mean. The estimated cost was 500,000 francs.

The Germans, moreover, along all important lines have built, or are building, "Interrupting Forts," so that an enemy would not be able to work the line, even if he turned the one or two fortresses with loop lines, as the Germans themselves did at Metz. They also decided after the last war that all important railway bridges, especially those over the Rhine, ought to be defended in future. A wise decision doubtless, and carried out on a thoroughly German method. The company to which the concession is granted has to pay, in return for the privilege of being allowed to build the bridge, an indemnity, with which to erect works to defend it, or else to erect the works itself. For example, before being allowed to build the railway bridge at Wesel (Paris-Hamburg Line) the company had to pay 300,000 thalers to the Minister of War to build a fort to defend it.—(*n*).

*Repairing Trains to be ready.*

Trains must be kept ready, loaded with baulks, sleepers, rails, and everything necessary for speedily reconstructing any portion of the line. Lee always had such trains prepared during the American civil war, and found them of great use, as did also the French in 1870. It should be remarked that at each of the stations separate wagons should be kept loaded with the *particular* stores required for rebuilding each of the bridges, &c., in the neighbourhood.—(*c*).

*Examples of Details of Defence—American—Russian.*

General McDowell's orders for guarding the military railroads in the Department of the Rappahannock (*See* "Hand Book for Field Service," p. 281) were:—

1. Twelve sentinels along the track to each mile.
2. Three sentries to each post, with two-hour reliefs.
3. Blockhouses to be erected at intervals. Bushes and trees cleared away.
4. Each post to have white and red flags, and lantern for signalling.
5. At least one blockhouse at each bridge; special guards told off to watch, defend, and aid (if needed) in its repair.

6. Blockhouses where roads cross, with pickets thrown forward.

The other example we have chosen is from the Russian autumn manœuvres, near Warsaw, last year, which included the defence of a railway, about 120 versts long (80 miles). The means adopted were (we are quoting the *Invalide Russe*) :—

1. Posts of Cossacks, established at intervals along the line, which is also scoured (*sillonnée*) by patrols.

2. A troop of cavalry 40 to 60 versts in front to give notice of the enemy's approach.

3. Infantry out-posts, 'echeloned' parallel to the line, a short distance from it.

4. The most important points of the railway (extending over 80 versts) occupied by defensive posts (we regret not being able to give the details of these works).

5. All the administrative authorities and the police charged to look over their respective limits.

The troops allowed for the defence of this railway were, 2 sotnias of cossacks, and 12 companies of infantry.*—(*c*).

### *Reconnaissance of a Line for Repairs.*

The following mode of reconnaissance is somewhat similar to that adopted by the Germans, and seems suitable for the purpose :—

Three or four light trollies, worked by hand, precede the train, the first about 800 paces in advance, the others half way between it and the train. An officer and four men, with a bugler, accompany the first trolly, and cavalry scouts keep in advance of it on either side. The main portion of the train with two engines, one in front and one behind, should consist of wagons partly for the conveyance of troops and partly for the carriage of materials for the repair of the line; the men can sit on the loaded wagons, but if it is probable that horses will have to be conveyed, some end loading wagons ought to form part of the train.

If field guns are carried they should be in the rear trucks, in order that on an alarm being given they can be uncoupled and taken by the rear engine at once out of range to be unloaded.

The men on the trollies should carefully examine the line in all its parts, and, on coming to an obstruction, or within reach of an

* Early in the present war the Roumanian railway was patrolled night and day by Cossacks, and there were piquets at every bridge.

enemy, signal to the train behind, which attends to the warning.*—(*b*).

As regards carrying out the reconnaissance in a hostile country, it could best be performed by an officer, with an infantry escort, going along the line, flanked by cavalry parties on each side. Whenever possible, a wagon, or trolly loaded with stones, should be drawn over the line (by horses), both to test the uniform width between the rails, and the presence of mines. It is heedless to add that every precaution must be taken, such as not entering a tunnel till possessed of both ends, &c.

When it is required to *speedily* reconnoitre and re-construct an enemy's line, the best method is that adopted by the Prussians in Bohemia. Trains, fully loaded with men and tools, were preceded by a wagon someway ahead, with a few men to make reconnaissances, and *temporarily* repair *small* breaks, so that the train could pass on, detaching some men to repair permanently. A good deal of time is thus saved. An extra engine followed behind the train to take back messages or bring up supplies.—(*c*).

*Protection of Trains against Musketry Fire.*

It is almost impossible for infantry or cavalry to stop a train if proper precautions are taken, unless they are able to place obstacles on the line of rails or destroy portions of the permanent way. There are a few working parts of the engine which might be slightly injured and bent by bullets striking them at short ranges, but by the use of tank engines and protecting the vulnerable places with ¼-inch steel plate the engine would be practically invulnerable. The driver's and stoker's places should be protected in the same manner.

Infantry can be carried protected in the same manner in wagons covered at the side by ¼-inch steel plating, which adds but little to the weight to be carried.—(*b*).

*Railway passing through a Fortress.*

The particular defence of certain points in a line may be regarded strategically and tactically.

In connection with the first point Jacqmin observes, that the defence of lines of railways is intimately connected with that of the fortresses of the country. In first class fortresses, or intrenched

* If ordinary locomotives and rolling stock are procurable, the trains can be made of service in carrying infantry. If steam sappers and their wagons are only available, they will not be of much use beyond carrying materials; but if obstructions are probable the latter will be more suitable, as they may be able to change their wheels, reach the other side, and proceed along the line again.

camps of detached forts, a railway can usually be laid out without its course being affected by military considerations. The most important point in these cases is the possibility of the place being turned (as regards railway communication) by means of a diversion line, *e.g.*, the German made a diversion line of 32 kilomètres from Remilly to Pont à Mousson to avoid the fortress of Metz. In most cases the presence of a large fortress would prevent such a work being carried out, but in this instance the investment was too vigorous to allow of interference.

In this connection Jacqmin raises the point whether " local interests " may not lead to the construction of lines, which in a military sense, may nullify the value of a fortress. The line above mentioned was proposed for construction by the French local authorities before the war, but not carried out. If it had been the Germans would have profited most by it.

In second class and smaller fortresses the position of the line of railway should, as far as possible, be subordinated to defensive considerations. The successful defence of such places may deprive the enemy of any use of the lines near them ; of this the defence of Bitche is a case in point.

As a general rule, disregarding for the time fortresses, large stations and important junctions will be strategical points for defence, their possession being essential to the use of considerable lengths of line.—(*a*).

*Defence of Large Junctions.*

In connection with this idea Jacqmin cites the War of 1870-1 as giving examples of the preference shown for bombardments over regular sieges, and recommends the entire separation of all military defence from civil conditions.

With this view, important points on a railway should be defended by purely military works ; that is by works giving protection to no one but their own garrisons.

Though from existing conditions it would be hardly possible to get rid of the presence of civil inhabitants from railway junctions, the defence of the latter should be as distant from the town as possible, approaching more to the conditions of an intrenched camp. With this view the defence should consist of a line of field works commanding the approaches, containing cover for their defenders, and assisted by a covering force.—(*a*).

*Defence of Bridges.*

The defence of a large bridge requires an earthwork of some description, as a *tête du pont*, on the side of the river from which the attack will be made. The trace of this work depends on the features of the ground, but if secured against assault by palisading across its rear, it should not prevent its being seen into and commanded from the opposite side.

Railway materials give great facility in the construction of caponiers, splinter proofs, &c., which should be taken advantage of to make the earthwork as strong as possible.

Artillery, except in special cases, such as the defence of very long bridges, should be kept on the side of the river furthest away from the enemy's approach, and, if necessary, placed in very exposed positions in field Haxo casemates, made out of railway sleepers and rails or screened and under the cover of gun pits, so as to enfilade the faces of the earthwork on the opposite side, and cover the ground in front of it with its fire.

Care should be taken to provide a retreat for the defenders in case the bridge is destroyed by artillery fire. If there is a rapid river underneath it a flying bridge, or rafts below the bridge site, is the most practical arrangement.

* * * * * *

If the bridge be over a navigable river it may be liable to an attack by water; it will rarely happen that its safety will be imperilled by trees floated down to destroy the piers, but with wooden piles and a rapid current this mode of destruction is quite possible. It is best guarded against by stationing parties up stream to guide the floating obstructions through the openings, breaking them first up to a convenient size. If an attack is expected by boats, a wire rope should be stretched across the river at the level of the water, and some distance from the bridge, forming a boom to detain the boats at a place which should be under the effective fire of artillery and musketry.

A similar boom on the up stream side would be very useful to prevent floating substances coming down at night striking against the piers of the bridge.*—(*b*).

NOTE BY THE LATE COLONEL R. HOME, C.B.—Is not true defence a proper system of patrols?

* This is a common expedient in rivers in India, which, during heavy floods, carry down large trees; during the day they are guided through the bridge openings, and at night collected by the boom.

*Raids on the Line.*

Raids made by small bodies of men (called by the French *éclaireurs*), simply with the object of rapidly destroying a portion of the line and retreating before any resistance can be attempted, should be specially guarded against.*—(*b*).

SECTION 9. SPECIAL RAILWAYS FOR WAR PURPOSES.

*Description of a Military Tramway.*

A military tramway will rarely be used for the carriage of troops, its main object will be the transport of stores at a low speed, and for this purpose the engines and rolling stock should be as simple and as light as possible.

The engines suited for the purpose are four-wheeled, coupled, tank locomotives, weighing about 12 tons each; the wheel base should be reduced as much as possible to facilitate their running round sharp curves. Engines of this type would haul trains of from 60 to 80 tons, and ascend inclines of 1 in 40, which should be the limiting gradient of the line.

Having fixed the weight of the engines, the rails suitable to bear them can be determined. The description best adapted for the line is a single flanged rail, weighing about 35 lbs. per yard; a lighter one cannot be laid without the probability of its bending between the sleepers, under the weight of the engines.

The rails should be in lengths of 24 feet†, and there should be nine sleepers to each pair, those next the joints being 2′ 6″ apart, and the others nearly 2′ 9″.

It is considered essential that fishplates should be used, as the line would scarcely be safe without them for traffic, and in a badly ballasted line they help greatly to keep it together.

The sleepers, if of wood, should be at least 8′ × 9″ × 3″, and if the railway is to remain down for any time thicker sleepers will be preferable.—(*b*).

*Rate of Construction of a Military Tramway.*

Such a line as above described can be rapidly made, and unless unusual difficult country be met with, the rate at which the plate-

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* Numerous instances of these raids occurred during the American War. In the Franco-German War the French employed a very large number of men in the defence of railway stations.

† Some rails of shorter lengths should also be provided.

laying progresses, when working from one end will limit the progress of the work.*

If large working parties are available, and the stores can be brought up without delay, with a properly organized Railway Corps, $1\frac{1}{4}$ miles per day ought to be calculated upon. This is very rapid working for a continuance, and can only be expected with special materials and special men, but it is quite within the limits of what has and can be done.—(*b*).

*Example of Construction of Military Tramway in India.*

There are many instances of rapid platelaying which can be gleaned from the records of the construction of railways, but the one which affords the best example of the progress which ought to be made in a light military railway is to be found in the *Professional Papers, Indian Engineering*, Vol. IV., No. 15. The "Durbungah Temporary Railway," a line of 51 miles in length, which was laid during the Bengal Famine, for the conveyance of food to the distressed districts. On the 10th February, 1874, Col. Stanton, R.E. (Bengal), then at Delhi, many hundred miles distant from the scene of operations, received order by telegram to organise labour and construct the line, which was to be made on the metre gauge, with rails weighing 40 lbs. per yard, and deodar sleepers (almost as heavy a permanent way as the pot-sleepers and rails recommended for military purposes).

There were heavy earthworks, also a number of bridges on the line, and the materials for the permanent way and the rolling stock had all to be crossed over the River Ganges, at the base of operations.

The first rails were laid on the 23rd of February, but as the fish-plates did not arrive until the 3rd March, but little progress was made until the latter date. The first train ran into the terminus on the 15th April, the 51 miles of railway with its embankments, cuttings and bridges being made in 56 days, and the platelaying done in 43 days. The line carried between the 3rd April and the end of May 32,000 tons of grain, exclusive of railway material, which delayed the traffic considerably. The average strength of the working parties was about 1,000 men; they were largely composed of a pioneer regiment, native infantry and native sappers.

* The men employed on a work of this nature should be practised at it, for nothing is more fatal to progress than to have to teach men their work when they ought to be proficient at it; better far not to undertake a railway than to make it a drag on the available labour, without giving a return for the work expended on it. If it be determined to have one at the seat of war it should go complete in everything, and ready to be pushed on as rapidly as possible.

There is not any reason why a military line in time of war should not be constructed at as rapid a rate and do as good service as this one.—(*b*).

*Working Party Required.*

It is difficult to estimate beforehand, the number of men required for the construction of a light railway. If inexperienced military working parties are used, the work done by them, at least at first, will be far below the usual average with other labourers.

The following is a rough estimate in a moderately easy country of the number of men required (military working parties), for the construction of the line:—

| | Sappers and Railway Corps. | Infantry Labourers. |
|---|---|---|
| I. Earthwork and bridge-making in advance of platelaying parties ... ... ... | 80 | 400 |
| II. Platelaying parties, unloading trains and carrying materials for permanent way, ... | 20 | 50 |
| III. Ballasting and completing the line ... | 10 | 100 |
| IV. Loading materials for permanent way in trains ... ... ... ... | 10 | 50 |
| V. Working trains (railway purposes only), watering and fuel arrangements, laying sidings, &c., &c. ... ... ... ... | 30 | 100 |
| Total,............................ | 150 | 700 |

Or one company of sappers and seven companies of infantry.*—(*b*).

*Bridges.*

The bridges are a source of delay, if special arrangements are not made beforehand for their construction; often those of existing roads can be strengthened and used, effecting a great saving in labour. Timber will almost exclusively be used for these structures. Small plate girders up to 25 feet span ought to be provided. The largest size will weigh about $1\frac{1}{4}$ ton each, and can be readily fixed in position.†(*b*).

* A liberal allowance must be made for sickness, and for the men employed on camp duties.

† In Abyssinia similar girders were sent from Bombay, and proved most useful; they do not require any bed plates and can be laid on a baulk of timber.

*Water for Engines.*

Arrangements for watering the engines require careful consideration. With slow and heavy traffic the water stations ought not to be more than seven miles apart. The engines should be fed from a raised tank, from which the water will flow, by gravitation, rapidly into their tanks; the amount required per day for each is about 1200 gallons.* Bad water is fatal to the proper working of a locomotive, and will rapidly send it to the repairing shops, while brackish water often causes it to prime, and makes it impossible to keep up steam.—(*b*).

*Description of Rolling Stock.*

A military tramway will rarely be used for the carriage of troops, and its rolling stock should be as simple and light as possible.

Open, low-sided spring wagons, with a wheel base of about five feet, and about 12 feet long, with spring buffers, and weighing about 30 cwt., should form the greater portion of the rolling stock. Some covered wagons, especially those fitted as ambulances, will be necessary, also high-sided wagons for the conveyance of horses, cattle, and forage. A few passenger carriages are also desirable for officers, invalids, &c., and guards' brakes are very convenient.

Special wagons are necessary for carrying rails (which are 24 feet long.) Two platform trucks, with a horizontal bolster of wood, working on a vertical pivot, in the centre of each platform, is the most convenient arrangement; the rails rest on the bolsters and allow the wheels of the wagons to adjust themselves to the sharpest curves. Stations are hardly necessary, but cover of some kind should be obtained for the engines when not employed, and store sheds are desirable at each terminus. After the railway has been worked for some time trifling repairs to the rolling stock will be required, and emergent repairs may be necessary at any time; for this purpose it is essential that a small workshop should be provided; but the fewer repairs undertaken the better, as they require skilled labour; the necessity for them should be obviated as much as possible by the supply of duplicate parts liable to damage, which should be made interchangeable among the rolling stock.†—(*b*).

*Rate of Daily Traffic.*

The trains, including stoppages, will not travel at a greater speed than 10 miles per hour, and if the sidings are 7 miles apart they

* This is for a very light engine.

† In Abyssinia a locomotive was sent up from Bombay, which had to be fitted, before a month on the line, with new driving wheels. Fortunately spare ones had been sent.

cannot follow each other at less intervals than an hour and a half, to allow the return trains to use the line, or about 10 trains daily can be despatched.* As many of the stores, particularly forage, are very bulky, about 400 tons a day will be as much as should be counted upon for despatch, but under great pressure this might be doubled, if rolling stock be available.—(*b*).

*Rolling Stock Required.*

To despatch 10 trains a day the following rolling stock will be required. It includes about 30 per cent. spare engines, and 25 per cent. spare wagons†; twelve wagons are the number calculated to make up each train, the net weight of which will be forty tons.

| | Length of Railway. | | | |
|---|---|---|---|---|
| | 0 to 15 miles. | 15 to 30. | 30 to 45. | 45 to 60. |
| Engines 10 to 12 tons each. | 6 | 8 | 10 | 13 |
| Wagons, 12 to each train, and 1 train loading at the end ... ... ... ... ... | 75 | 90 | 115 | 150 |
| Guards' vans ... ... ... | 4 | 6 | 8 | 10 |

In addition, the number of passenger carriages, ambulances, &c., which are luxuries and not necessities, will vary according to the strength of the army and the character of the campaign. The surplus rolling stock will require extra sidings and will be in the way at the terminus, and on this account should be avoided.—(*b*).

*Description of Rails for Military Railways and Mode of Shipping.*

Whatever style of semi-permanent way would be adopted, two points are quite clear, more particularly after our experience in Abyssinia.

1st. That the material should be uniform in character, section of rails, &c.

2nd. That whatever is sent out should come in complete sections of line, not rails in one ship, sleepers in another, fastenings in a third.

* A train will take from 30 to 40 minutes to reach the first siding, 7 miles distant; the return train, which should at once start on its arrival, will accomplish the same distance (being empty) in perhaps five minutes less; so that an hour and a quarter should be sufficient to clear the line, and the next train could be despatched an hour and a half after the first one. An hour and a half to two hours should be allowed for loading each train, and half to one hour for unloading.

† It is usual even to allow a larger number of spare engines and wagons, but as the rolling stock will be new this proportion will probably be sufficient.

Also that *old* material is very awkward to use; rails are bent and more difficult to lay than when new.

The reports of the C.R.E. in Abyssinia is conclusive on these points.

The rail should not be too light; unless the line is strong enough for the ordinary traffic the line can never be kept in proper order, and there will always be risk of accidents. A light rail will last for a time if the ground is exceptionally good, and if laid on a longitudinal sleeper.

This mode of laying is both costly and troublesome, and it is believed that in the long run it will be cheaper to employ a heavier rail. A flanged rail of about 36 lbs. per yard would probably be sufficient for ordinary traffic, but if any but the very lightest engines were used the rail should be heavier, say—40 to 45 lbs. If the metre gauge were adopted a 36-lb. rail would answer very well.

Points and crossings should be formed of the same rail, to do away with chairs. A certain number should be prepared beforehand to an uniform lead of one in six, which is about the most convenient. They need not be kept fitted together, but all the different portions should be packed up and sent together. The flanges of the rails should be drilled for spikes, so as to allow the guard rails to fit sufficiently close, and iron plates, also drilled, should be provided, to fit under the points of the crossing and the knuckles of the wing rails, to prevent them cutting into the sleepers.

As there are no slide chairs, iron plates, notched in section, should be provided, so as to allow the points to rise slightly, and fit home over the flanges of the stock rails. Unless this is done the points will not fit close, and be liable to be bent and injured by traffic.

If the points are required to be self-closing, a shot or other weight may be slung on the handle.—(*a*).

*Railway for Siege.*

It is scarcely probable that a siege will be undertaken in future without a military tramway being constructed to assist in bringing up the siege train, ammunition, and stores, should a local railway not be available for the purpose; for the labour expended on such a line will almost, without exception, be repaid by the increased facility in the transport of heavy materials.

The terminus of the line, in such a case, should be at the depôts of the besieging force, which will, of course, be out of the reach of sorties, and sidings should be made for wagons and engines. It is a matter of some importance to have a plentiful and good supply of water at the place where the engines are kept, to fill and wash them out when necessary. Branch lines should be constructed to the R.A. and R.E. parks, which will be at about $3\frac{1}{2}$ and 3 miles distance respectively from the fortress.* The line from the R.A. and R.E. parks, if continued further, becomes a trench railway, and the objects of its construction will be :—

1. To move to their position heavy guns, platform materials, &c., &c.

2. To supply the siege batteries with ammunition.

3. To bring up reinforcements rapidly in case of a sortie, and to convey working parties, with their tools and materials, to and from their work.—(*b*).

*Break of Gauge.*

In the vicinity of a fortress there will nearly always be found some lines of railway, portions of which may be useful to the assailants for running trains over, this is a reason why a military line should, if constructed, be on the same or narrower gauge.

The Russo-Turkish war affords an instance of the evils of a break of gauge. Russia adopted one of 5 feet 3 inches for her railways, in order that the rolling stock of the different foreign lines leading to her fortresses, (which are on the 4 foot $8\frac{1}{2}$ inch gauge), might not be able to run over hers in case of invasion. This affords very small security, for experience of American railways has proved that the altering of one rail on a sleeper, provided it is to diminish and not increase the gauge, can be very rapidly carried out. It is not so easy to widen the gauge, as sleepers, bridges, platforms, &c., may not permit of the alteration, and as the Russian rolling stock could not be taken over the Roumanian lines, there existed all the evils of break of gauge, and the consequent curtailment of the carrying power of the line.—(*b*).

*Special Plant Necessary.*

In Abyssinia, old rails were sent from Kurrachee for the railway; they had been used for sharp curves, and were difficult to straighten. When laid they make a very bad line, and sometimes broke between sleepers; progress was very much delayed by the necessity of using such bad material.—(*b*).

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* There can be no advantage in placing the terminus at the R.A. or R.E. parks. All the materials and stores are for siege purposes, and are not required to be loaded into trains again. There is no object in keeping empty waggons at either place.

*Wire Tramway.*

As the greater portion of the stores for an army in the field—such as food, forage, arms, ammunition, clothing, &c., are capable of being packed in comparatively small packages, the practicability of restoring communication almost at once, over a breach in a line of railway, by a wire tramway seems easily feasible. The size most suited for the purpose, is one capable of transporting loads of 1 cwt. at a time, and which in a day of 10 hours would be capable of carrying 100 tons each way. The weight of such a tramway, exclusive of the posts which average 25 to the mile in level country, and including rolling stock, would be about 15 tons per mile, and the rate of construction would be up to 3 miles in two days; for very short distances it could be erected in a few hours. The objection to these suspended tramways is the liability of the wire rope running off at angles or sharp curves, and the consequence of it doing so, that a long length becomes frayed and damaged before it is discovered that something is wrong, but there would be a minimum risk of injury for the purpose for which it is proposed.

Suspended wire tramways suited for carrying the stores of an army in the field over short distances, of from 100 yards to 3 miles, intended to be worked by a steam sapper at one end, and usually known as Hodgson's suspended wire tramways, have been erected in all parts of the world; the wire rope forms an endless band, which is passed over horizontal pulleys at both ends, one of which is driven by a motive power; the rope is passed over pulleys fixed to posts which are placed about 200 feet apart, and the loads, in suspended cradles, are placed on the revolving rope and carried along with it; the centre of gravity of the load being below its point of suspension, it does not fall off, and the friction between the rope and the bearing surface of the cradle enables the load to be carried even up steep inclines of 1 in 10. The speed is about 3 miles per hour.

Other plans can be resorted to for the conveyance of stores across a chasm, one of the best, which is suitable for spans up to 600 feet, is as follows:—Two long poles are erected at one side like a pair of shears, over which are strained two steel wire ropes (of about two inches circumference, and weighing about 1·75 lbs. per yard). On each of these ropes slides a pulley with a cradle suspended from it, and these pulleys are connected by a smaller steel wire rope passing over a horizontal wheel, about 2 feet in diameter, fitted with a band brake. The two heavier ropes form two inclines across the obstruction, for the conveyance of stores suspended from the pulleys, while the length of the smaller rope, connecting the cradles, is so arranged that when one cradle is at one side to receive its load, the other will be at the opposite side to be unloaded. The cradles are loaded at the ground level, hauled up to the upper platform, either by men, horses, or engine power, hooked on to the pulley on the wire rope, and shot across to the other side, by running down the incline; the empty cradle on the other rope being pulled up and the speed regulated by a man at the brake. In this manner loads up to 5 cwt. can be rapidly transported over short distances, and the line is capable of carrying a very large quantity of stores daily.*

The manager of a Land Enclosure Company, in Holland, writes (Aug. 1877) as follows regarding a line in his charge one mile long, capable of conveying 80 tons a day, and which is worked by a 6-horse-power portable engine. "With 20 men I can take down the line and put it up again in a fresh place, 5 miles distant, in one day."—(*b*).

*Traction Engines.*

Traction engines are to be seen year after year, moving about some of the most hilly counties in England;† over bye roads, through deep mud, and across cultivated fields, in all weathers, holding more than their own against horses which are carefully fed and housed. In a campaign where the horse has everything against him the advantage in favour of the traction engine will be immensely increased.

The service traction engine, which has been adapted by its makers to run as a light locomotive on a gauge of 4′ $8\frac{1}{2}$″, has been proved by extended trials to be a very serviceable and light engine,‡ travelling at a low rate of speed. The following table shows the capabilities of the service traction engine as a road engine and a locomotive:—

| | As Road Engine. | As Locomotive. |
|---|---|---|
| 1.—Weight of engine with water and fire | $6\frac{1}{4}$ tons | 7 tons. |
| 2.—Steepest incline up which it will move with ordinary load | 1 in 10 | 1 in 30 |

* Similar means are adopted in mountainous districts, even up to 1,200 yards, for the transport of ores from works in a hill side to places below.

† For ploughing purposes.

‡ Several of these Steam Sappers have been running for the past 4 years on the short but hilly tramway at Upnor, opposite to Chatham. They are very slow, being worked by teeth gearing, but a fast pinion can be substituted in the train of wheels which permits of a speed of 7 to 8 miles per hour being obtained.

| | As Road Engine. | As Locomotive. |
|---|---|---|
| 3.—Maximum load up a gradient of 1 in 10 as road engine and 1 in 40, as locomotive (gross) | about 16 tons | about 20 |
| 4.—Approximate speed in miles per hour on the level | $2\frac{1}{2}$ miles. | 3 miles. |
| 5.—Average consumption of good steam coal per hour with maximum load | $\frac{3}{4}$ cwt. | $\frac{2}{3}$ cwt. |

The consumption of wood, which they burn freely, is about double the weight of coal.—(*b*).

## Section 10. Organisation for Working Railways in War Time.

*Jacquin on the necessity of Previous Organisation.*

Jacquin remarks on this that the moment when military transports have to be effected is not the time for the railway companies to arrange how to carry them out.

The Austrian regulations on this head are very precise, and lay down:—All railway companies are obliged to include in their time tables a certain number of military trains which should suffice for the ordinary requirements of the military authorities.—(*a*).

*Necessity of Previous Organisation exemplified in the War of* 1870-1.

In his account of the railway operations about Le Mans, Reimes, and Laval, Jacquin gives a terrible description of the confusion produced by want of authority; first to arrange the transport, and secondly to *keep* to the order. Also in the movements of the 19th army corps of 32,000 men, 3,000 horses, 300 guns and carriages from Cherbourg to Alençon, incessant orders and counter orders produced great delays; troops arrived late; the embarkation was very slow, two or three hours for each train; officers neglecting to look after their men; men refusing to get into goods' trucks. The evacuation of Dôle is another instance of want of order and arrangement. Orders received one hour were countermanded the next; trains were sent backwards and forwards instead of being removed at once; a large portion of one main line was used as a siding, and time was wasted by selecting the wagons to be removed (provisions, &c.) instead of running them away as they came. The result was that the Prussians succeeded in capturing a quantity of rolling stock which ought never to have fallen into their hands.

The condition of the station at Metz soon after the outbreak of the war is, perhaps, even a still more forcible illustration of the evils arising from want of order in military transports. Everyone, from the highest to the lowest, gave orders. Train after train of infantry arrived without orders as to where the men were to go; the men got out, but the baggage accumulated; the same occurred with cavalry, artillery, and stores. In addition to this the railway company's servants and vans were employed in carting the various stores which arrived to the different departments, and not unfrequently receiving the same back again for re-transmission. The natural consequence of this was that every station, siding, &c., in Metz was crammed with trucks full of stores, provisions, &c., and it was so far fortunate for the garrison when invested that few of these had been removed without being emptied, and that their contents were thus made available. Also, a number of covered trucks and carriages, remaining in Metz owing to the confusion, were made use of as a species of temporary hospital; these accidental advantages should not, however, be allowed to obscure the immensely greater evils by which they were produced.—(*a*).

*Necessity of Previous Organisation in England.*

In England the railways having been made without any regard for their use for military purposes, and being worked without State intervention, it can be hardly expected that if the lines were suddenly monopolized and used to their utmost capacity to convey troops and military stores, some confusion and misunderstanding would not be inevitable. On the main lines, which possess an enormous passenger traffic, the railway officials will probably be equal to the emergency; but the concentration may be directed on a branch which will have to bear a traffic which it was never anticipated would be thrown upon it. Directing heads and practised hands will be needed to prevent men, animals, and stores becoming mixed in hopeless confusion.* Rapid concentration will entail endless disorder if the component parts of the different arms of the service are not kept together with their supplies of food, ammunition and stores.

It therefore seems essential in order to secure the full advantages of rapid concentration by means of our admirable system of railways,

* The greatest confusion existed in the French lines at the commencement of the war of 1870-71, which appears to have been the result of want of organisation in the French army, and shows the necessity of having officers who understand and are practised in the movements of large bodies of troops by rail to arrange the transport in conjunction with the railway authorities. Both at the departure and arrival stations the different corps were mixed, regiments were separated from their baggage, and soldiers sought their comrades in vain.

that there should be special officers knowing the officials of each line, accustomed to work with them, and thoroughly acquainted with all particulars regarding the lines under their surveillance. They should be ready to take charge of the movements of troops and carry out the preparations for doing so, which have been enumerated a few pages back.

The Quartermaster General ought to be able, from the information furnished by these officers, and the plans of different railways, to direct with certainty the concentration of the different army corps, and to determine the lines over which they ought to be moved, and the extent to which the public traffic ought to be allowed; to assist in this determination the co-operation of the most practised railway officials of the different lines is essential, and ought to be at his service.—(*b*).

*Working of Railways by an Invader.*

It has previously been stated in these pages that as an invading army advances along a line of railway it will be necessary first to restore communication along it by temporary and expeditious means. After this has been done, and the line is ready for traffic with the ordinary rolling stock, there are various duties connected with its working and its repairs, which will be much better done by trained civilians than by soldiers.*

Stations will have to be opened at new places to supply the wants of the different army corps; labourers will be required for loading and unloading trains; men for the repair of the line, and mechanics for the repair of the rolling stock. There is scarcely an instance of all the railway *employés* refusing to take service under the invader (especially in the lower grades), and they should, if possible, be retained. On the other hand the working staff will probably have to be greatly increased, and it may not be safe to entrust the charge of trains to men who have no sympathy with the invaders. For all duties connected with the service of the army in the immediate vicinity of the opposing forces, the employment of a railway corps is a necessity; the men composing it must be disciplined soldiers, instructed in drill, and the power of defending themselves, and under the orders of the commander-in-chief. As the military trains will have to proceed at a slow rate, and will be very

* It should not be forgotten that towns served by railways, and districts through which they run, are often dependent upon them for supplies of food, and this applies with special force in time of war, when agriculture is less attended to, and there is a greater drain on the food supplies.

simple in their composition, the want of experience of the line will not be of great importance.—(*b*).

*German Organisation.*

The organisation requisite to ensure the full development of railway service in war may be divided into two portions, which, however, are very intimately connected in some respects—namely, organisation for working, and organisation for construction.

The latter will be considered more particularly when discussing the formation of a railway corps.

In connection with the former point, it is proposed briefly to examine the practice of other nations in this respect, notably, the Germans, whose system is probably the most complete of any.

The principle at the bottom of all rules on the subject is the constant juxta-position of the military and technical elements. Everything should be done by two inseparable functionaries—a staff officer and a professional railway official.

The military authority commands, but the professional element intervenes at any moment to rectify mistakes. In his general *resumé* of the railway organisation of Germany, Austro-Hungary, and Belgium, Jacqmin observes:—"In time of peace each railway is studied and examined as regards the services it can render under the direction of the general staff.

"Staff officers, assisted, *doubled*, if we may use the word, by a railway official, practice drawing up, as quickly as possible, time tables for trains and movement of troops.

"When war begins each is at his post; his powers—*duties*, the German regulations call them perfectly defined; each knows what to do, and does it. An executive committee, or chief of field railways and staff follow headquarters; military railway directors are entrusted with the different works to be carried out by the railway department, and at important points Route-station Commandants and military station masters ensure order."—(*a*).

*Austro-Hungarian Organisation.*

In Austro-Hungary a central committee is appointed, sitting in Vienna, composed of military officials, delegates from the railway companies, &c., and is to "take all measures requisite to ensure the best employment of the railways in time of war."

The central committee is the only authority for all measures, communications, or modifications in connection with military transports; no authority but that of the minister of war can interfere with its working.—(*a*).

*Austro-Hungarian and German Field Transport Systems.*

For transport in the field when war is declared, a Field Railway Transport Committee (Germany, Chief of Field Railways, and Staff) is appointed, acting under the Central Committee at Vienna. Its composition is similar in nature, and it is attached to the general headquarters. Its duties are to inspect the railways on the theatre of operations; direct their working both from the military and technical points of view; arrange transports so as to best utilize the lines; protect lines and material, and arrange for the construction of new branches, sidings, &c.

Subordinate to this executive committee are smaller Line Committees (Germany, Military Railway Directors, Railway Line Commandants), it being considered that the Executive Committee would not be able properly to supervise important transports over several lines at one time. These Line Committees are composed of a staff officer and a railway official, and take charge of the details of transport, &c., over each line.

In Austro-Hungary their jurisdiction extends over an average length of 784 kilomètres (about 470 English miles), and over this they have charge of the arrangements for loading and unloading trains, providing food for troops *en route*, &c. Under the Executive Committee, or Central Committee, they draw up the necessary military time-tables. When transports commence they regulate the composition, speed, and succession of the trains.—(*a*).

*Route Station Commandants—Austro-Hungarian and German.*

At certain stations along the lines of communication an officer is placed in charge of the route service, so dividing the whole length into small sections, in which every detail is attended to, and order and regularity enforced. The duties of these officers, termed Route Station Commandants, is under the Austrian regulations, briefly as follows:—

Under the route service authorities they are in absolute charge of the route station, and give all orders relative to the embarkation of troops, supply of provisions, quarters for sick and wounded, if halted there; see to all details connected with transport; at departure stations see to the loading and starting of trains; condition of rolling stock; use of material to the best advantage; see that loading platforms are kept clear.

At arrival stations attend to the rapid unloading of the trains, and immediate return of empties.

At junctions arrange for the proper division and re-arrangement of trains.

At halting places see that the refreshment arrangements for the troops are complete.

The Commandant, or his assistant, should always be present when trains arrive and leave. They are specially charged with the defence of the station, and despatch of stragglers to their regiments.

In Germany the duties of a Route Station Commandant are slightly different, as the railway service is taken out of the hands of the route authorities and forms a department of its own.—(*a*).

*German Etappen Regulations.*

The following outline of the system adopted by the Imperial Government in Germany, as modified by the experience gained in the war of 1870-1, is taken from a French version of the Prussian Etappen Regulations, translated by Lieut. D. O'Brien, R.E., those portions only which bear directly on railway transport being noticed.

The whole system of railway organisation is divided, geographically and personally.

Geographically :—

1.—Such home lines which are not interfered with, and on which the working to some extent remains as in peace, military transport being added.

2.—Lines, whether at home or abroad, which are prevented by the war from being worked by their usual staffs, or on which the ordinary service is abrogated.

At the points where these conditions change, "transfer-stations" are established. On the lines in rear of these stations the ordinary traffic will not be interfered with, except when absolutely necessary for military purposes. Beyond these stations military authority is paramount, and civil transport made secondary to military.

*Collecting* stations are established for each line leading to the army, where all trains of supplies from the different districts of a corps are collected, before being sent over the lines on the theatre of war. A collecting station is one of the chief magazines of the corps operating in the field, and should not be too far from the seat of war, but should not be also a transfer station, so as to avoid a block from accumulation of stores.

The personal division is as follows :—

1.—The Imperial Chancellor, and a "Central Committee" of delegates from those Federal States possessing a railway system, exercise a general supervision over all lines as regards their employment for military purposes. Subject to this general control, the military management of the whole of the railway service on the theatre of war and military transport upon home lines is, among other duties, directed by—

2.—The Inspector General of Communications; and for the special railway branch is appointed—

3.—The Chief of the Field Railways; under his orders are—

4.—The Railway Division of the General Staff at home for transport over lines not within the theatre of operations, and which are worked by their own staff.

5.—Military Railway Directors, for railways in the theatre of operations.

6.—Railway Line Commandants, in charge of transports over certain home lines under (4).

7.—Railway Station Commandants who are under (5) or (6), according to the position of their station.

On mobilization, the Imperial Chancellor, or, at his request, the Central Committee, decide what proportion of staff and rolling stock should be provided for army use by the different railway boards, who hand them over as wanted.

The Inspector General of Communications is usually a Lieutenant General, appointed to the post on the outbreak of war; during peace his railway duties are performed by the Chief of the General Staff. He remains usually at the Imperial Head Quarters, and under instructions from the Chief of the General Staff, has in in time of war, general superintendance of—

Route service.
Railway service.
Field intendance.
Field sanitary service.
Route telegraph.
Field postal service,

and is responsible for the regular and harmonious working of the departments under his charge.

At this point there occurs, in the German scheme, a separation between railway service proper, and route service, though both form portions of the "Etappen" or service of communications considered as a whole.—(o).

*German Field Railways.*

Previous to the war of 1870-1, the route and railway services were under one set of officials and this was found to produce bad results from—

1.—Too much work coming upon the department of the Route-Inspector-General.

2.—The impossibility of placing one line of railway at the disposal of each army, so as to allow the Route-Inspector-General's department to regulate its employment.

In order to remedy these defects, the railways are taken entirely out of the hands of the route authorities, but both the route-service, the railway-service, and other departments more or less connected with them, are united under the general control of one authority, who is able to regulate the different interests of each, and ensure their best co-operation in the common task of ministering to the wants of the army in the field. Leaving the other branches of the "Etappen" out of consideration, the next step in the railway staff is:—(a).

*The Chief of Field Railways.*

The Chief of the Field Railways, usually a Field Officer or Major General, takes up his duties on mobilization, and in accordance with the order received from the Inspector General, or from the Commander in Chief, arranges the necessary transport for stores, reserves, &c., and for the concentration of the Army Corps, organises the railway service at the seat of war, and, if required, makes new sidings, &c., and through the head of the Railway Division of the General Staff at home (4), regulates the military transport over home lines.

His staff is composed of—

The Officer Commanding the Railway Battalion and his Adjutant.

Two Staff Officers (1 Field Officer, 1 Captain).

Two superior railway engineers and subordinates.—(a).

*The Chief of the Railway Division.*

The Chief of the Railway Division of the General Staff at home, who is under the sole authority of the Chief of the Field Railways as regards his railway duties, is in charge of all transport arrangements on all lines *not* placed under Military Railway directors; that is, on all lines retaining their usual organisation.

In concert with the Imperial Chancellor or Central Committee 1), he apportions the traffic amongst the various lines and ensures the supply of provisions, &c., for the army, by constant reference to the home authorities.

He is assisted on technical subjects by railway officials attached to him for the purpose by the Imperial Chancellor.

Through the Railway Line Commandant (6), he regulates the necessary military traffic over the home lines, having military time tables drawn up for the purpose. He receives demands for transports from the theatre of war, and other quarters, and decides in accordance with the general or particular orders of the Chief of the Field Railways upon the urgency of each case.

In the case of transports which start from a home line, (or from a point outside the theatre of war, when the war is carried on within the limits of the Empire), notice is to be given to the Railway Line Commandant (6) when not more than one military train is required, otherwise to the Railway Division of the General Staff at home (4). (Transport which can be effected by the ordinary passenger or goods trains are not here referred to. These are arranged for direct with the railway managers, or the station masters, from whose stations they are to be sent). Notice of the transfer of a transport from one line to another is to be passed on by whoever receives the notice to all others concerned.

If communications with the Chief of the Field Railways should be interrupted, the Chief of the Railway Division will perform the duties of the former officer until they are re-established. He is, in fact, the executive officer for home line military transport.—(*a*).

*The Military Railway Director.*

A Colonel, with the title of Military Railway Director, is placed by the Chief of the Field Railways in charge of the whole, or, if the operations are extensive, a district of lines on occupied territory, or of such home lines on the theatre of war as are, through the war, prevented from carrying out the service without the assistance of the military authorities. His duties are—(1) to organise the train service over these lines and regulate transport arrangements, and (2) the technical working and management. To carry out his different duties he has complete control over the staff and rolling-stock of the various lines within his district, as well as over the military and technical staff placed under his orders.—(*a*).

*The Working Staff.*

The Staff of a Military Railway Director is organised as follows:—

The Director (a Field Officer).

Personal Staff.

Adjutant (a Captain).
Field Paymaster.
Field Intendant (with military chest, and staff of clerks, &c.)

Transport Staff, (1).

A Field Officer.
Adjutant (Captain or 1st-Lieutenant).
Staff Surgeon.
An official of the Intendance (part of the Director's personal staff).

The Field Officer is in charge of the transport department, and also acts for the Director in his absence.

Working staff (2) of a military Railway Director for a line of Railway of about 280 English miles.

| | |
|---|---|
| Manager's Office. | 1 1st-Captain, (or civilian engineer ranking as such) constructing railway engineer.<br>1 2nd-Captain, (or civilian engineer ranking as such) working railway engineer.<br>1 1st-Lieutenant, locomotive superintendent.<br>1 1st-Lieutenant in charge of manager's office.<br>20 N.C.O. and men as clerks and writers. |
| Engineer's Office. | 1 2nd-Captain, inspector of permanent way.<br>2 chief railway clerks.<br>2 draughtsmen.<br>2 working department clerks. |
| Accountant's Office. | 1 Accountant (military branch).<br>2 N.C.O., book-keepers.<br>1 N.C.O., military chest keeper. |
| Telegraph Office. | 1 Telegraph Inspector } military branch.<br>1 Assistant. } |

The working department is in charge of one of the railway engineers, who, in conjunction with the Director, is responsible for the efficient technical working of the line.—(a).

*Working Companies.*

The Military Railway Director is assisted in working the line, and in works of repair and enlargement by Railway-Working-Inspectors, and "working" companies of the railway battalion.

*N.B.*—"Working" is to be understood as management and maintenance, as opposed to construction.

According to the nature of the line, &c., an inspector and from two to four companies are told off to every 70 to 140 English miles.

Their constitution is as follows:—

Military working inspection for a line of Railway of 70 to 140 miles.

1 1st-Captain as working inspector and director.
1 1st-Lieutenant as railway engineer.
1 2nd-Lieutenant as 2nd railway engineer.
2 2nd-Lieutenants as locomotive engineer and assistant.
1 2nd-Lieutenant as working and line comptroller.
14 N.C.O.—4 as chief railway clerks; 1 foreman of shops; 1 superintendent of stores; 1 carriage foreman; 1 storekeeper; 1 telegraph overseer; 1 draughtsman; 4 writers.

Field Railway Company for working a line of Railway of about 28 to 37 English miles.

1 1st-Captain commanding.
1 1st-Lieutenant.
4 2nd-Lieutenants as station superintendents.
1 Company Serjeant Major.
40 N.C.O.—4 as station masters, or assistant station superintendents; 1 as booking clerk; 12 as engine drivers; 7 as train conductors and 7 as guards (baggage masters); 3 as permanent-way overseers; 6 as telegraphists.
20 Lance Corpls.—3 as guards; 1 as telegraph foreman; 2 as gangers of platelayers; 12 as stokers; 2 as stationary engine attendants.
139 men.—4 as makers up of trains; 18 as pointsmen; 14 as platelayers; 7 as workshop artificers; 4 as carriage greasers; 2 as engine cleaners; 55 as watchmen of line or gatemen; 35 as brakesmen.

The Military Railway Director should prepare the necessary time tables.

The Chief of the Field Railways will determine the average number of trains to be despatched daily.

The Director should pay particular attention to the establishment of refreshment stations, which should be at smaller intervals than ordinary, on account of the reduced speed of the trains, and the unforeseen stoppages that may occur.

Rations for the staff, and supplies for the refreshment stations, are obtained through the Intendance branch of the Director's staff.

Transport of which notice has been received, and which can be taken by the ordinary trains, should be attended to at once.

If, on the other hand, it might cause interference with the ordinary traffic, application must be made to the Chief of the Field Railways for instruction.—(*a*).

*The Railway Line Commandant.*

One field officer selected for this post by the chief of the general staff, and attached to the railway division (4) to learn their work. On mobilisation they report to the Chief of the Railway Division, who assigns them to their respective districts, and acquaints them with the movements of troops to be immediately effected.

The Railway Line Commandants should then draw up time tables, settle all details about transport, and make arrangements for supply of water, provision, forage, coals, &c. The officials of the various lines are to be informed by the Railway Line Commandants what amount of rolling stock, &c., they may be called upon to contribute in the event of occupation of the enemy's railroads. Rolling stock thus borrowed is to be marked, and considered *pro tem* as the property of the railway direction whose number it bears.—(*a*).

*Sick and Wounded.*

The conveyance of the sick and wounded from the stations of the sick-transport committee to the various hospitals in his district, is effected by the Railway Line Commandant. He should therefore be acquainted with the available hospital accommodation. To assist him a military surgeon or civil doctor is attached to his staff, which is composed of:—

1 Field Officer as Railway Line Commandant.
1 First Lieut. as Adjutant.
1 Paymaster.
1 Superior railway official and 1 assistant.
1 Surgeon.
1 Chief railway clerk and 1 office clerk.—(*a*).

*The Railway Station Commandant.*

Railway Station Commandants are officers appointed to take military charge of stations. If on occupied lines or on those on the theatre of war, they may be Field Officers, and mobilized, and are under a Military Railway Director (5). If on home lines, they are Captains, not mobilized, and under the Railway Line Commandant of their district (6). The ordinary station master is one of the staff of the Commandant, who is to assist him in carrying out the orders he receives for transport and to enforce strict adherance to the time tables, preserve order, prevent interruption of the traffic, and protect the station master and his staff from interference.

The Commandant is not to interfere with the station master on technical matters connected with the railway service. He will arrange, however, for all requirements of troops passing through his station or halting there, such as water, provisions, quarters, &c., in which duties he is assisted by an Adjutant and Commissariat officer. At stations where there is a *Route Station Commandant*, the authority of the Railway Station Commandant is restricted to his station, but complete co-operation between these two officers is most essential.

Where there is no Route Station Commandant the Railway Station Commandant will perform the duties appertaining to that officer, and which have been briefly described when speaking of the Austrian regulations.—(*a*).

*Importance of Trained Subordinates.*

The importance of having a trained staff of subordinates, as afforded by the railway battalion, was abundantly shewn by the difficulty experienced in 1870-1 in obtaining men to work the lines taken in France:—(*a*).

## SECTION 11. ORGANISATION OF A MILITARY RAILWAY CORPS.

*German System, War of* 1870-1; *Corps Employed on the Construction of a Line.*

Jacqmin gives the detail of the force employed in the construction of the diversion line at Pont-a-Mousson before referred to.

1 Captain Commanding.

Sections I. and IV. (Field railway-companies) 400 in all.

400 railway workmen.

4 companies of fortress pioneers.

1 squadron of cavalry to furnish patrols and requisition men and provisions from the neighbouring villages.

A field train of 250 carriages of tools and stores (each field railway-company has a train drawn by 60 horses, so in this case extra vehicles must have been used).—(*a*).

*German Railway Battalion.*

The battalion is recruited from the line. Recruits remain three years with the colours, three in the reserve, and six in the Landwehr. The battalion is divided into four companies, one of platelayers and watchmen, the others, stokers, artificers, telegraphists, &c. Technical and practical instruction is obtained on lines in process of construction and in workshops.

The first battalion was formed out of the existing companies and took over their materials.

Many one-year volunteers join the battalion, preferring a service in which they can obtain a professional education which may help them to employment in the railway service, to an ordinary regiment The State gains by having a number of better-educated men always passing through its hands, and who can be recalled when their services are required in time of war. The *battalion* is merely the *companies* united; it has the advantage of being more readily employed upon extensive works, and its requirements in the way of material are more likely to be attended to than those of smaller bodies.—(*a*).

*Austrian System.*

The Austrians prefer separate sections, ten in peace and fifteen in war. Each is composed of:—

1 Officer of Engineers.

1 Officer of Pioneers.

65 men of one year's service, and whose military instruction is kept up in winter and bad weather.

Technical instruction is obtained by the sections being hired out to the railway companies, who defray all expenses, and give a small daily pay to those they employ. * * * *

As a general question Jacqmin recommends the creation of a special corps for railway service, as the Engineers, however capable, have quite enough to do.—(*a*).

*Navvies in the Crimea.*

Major Powell, the Chief Superintendent of the line laid by us in the Crimea, speaks of the difficulty experienced in working the line with navvies and undisciplined men. "They often struck work when most urgently needed." It need hardly be said that a risk of this kind should not be run twice.—(*a*).

*American Railway Corps.*

The American War of Secession gives an example of the largest railway organisation that has ever been attempted to be formed in war; at one time during the war 24,964 men were employed on the military railroads (*Vide General McCallum's Report*).—(*a*).

*Order of American Secretary of State for appointment of Military Director and Superintendent of Railroads.*

"War Department, Washington City, D.C.
"February 11th, 1862.

"*Ordered*—That D. C. McCallum be, and he is hereby, appointed military director and superintendent of railroads in the United States with authority to enter upon, take possession of, hold, and use all railroads, engines, cars, locomotives, equipments, appendages, and appurtenances, that may be required for the transport of troops, arms, ammunition, and military supplies of the United States, and to do and perform all acts and things that may be necessary and proper to be done for the safe and speedy transport aforesaid.

"By order of the President, Commander-in-Chief of the Army and Navy of the United States.

"EDWIN M. STANTON,
"Secretary of War."—(*a*).

*General McCallum's Responsibility and Power.*

General McCallum, at the close of his report, says, "During February, 1862, I received the following important verbal order from the Secretary of War: 'I shall expect you to have in hand at all times the necessary men and materials to enable you to comply promptly with any order given, nor must there be any failure.'"—(*a*).

*Formation of First American Construction Corps.*

Early in 1863 a small Construction Corps was formed, consisting of about 300 men, which was the beginning of an organisation afterwards numbering in the east and west nearly 10,000. The design of the Corps was to combine a body of skilled workmen in each department of railroad construction and repairs, under competent engineers, supplied with abundant materials, tools, mechanical appliances, and transportation. They were formed into divisions, gangs, and squads, in charge, respectively, of supervisors, foremen, and sub-foremen, furnished with tents and field equipment. Storehouses were established at principal points with an ample stock of tools and materials.—(*a*).

*Transportation Department.*

General McCallum was appointed General Manager of all Railways in the Military Division of the Missisippi, and observes as follows:—"Two distinct departments were projected, the 'Transportation Department' embracing the operation and maintenance of all the lines in use, and the 'Construction Corps' for the reconstruction of the railroads which might fall into our hands as the army advanced.

"To each department a superintendent was appointed, the duties of the former 'being confined to the management of transportation on all railways in use in the military division, together with all necessary repairs to the same,' those of the latter 'will be confined more especially to the reconstruction and opening of new lines of railroad.'

"The Transportation Department embraced the following divisions or sub-departments:

"1. Conducting transportation, or managing the movements of trains.

"2. Maintenance of road and structures, or keeping the roadway, bridges, buildings, and other structures in repair, building new structures, rebuilding old ones when and where necessary.

"3. Maintenance of rolling-stock, keeping in order the locomotives and cars, and managing the shops where such work was done.

"For conducting transportation each principal line was worked by a superintendent of transportation, who was held responsible for the movement of all trains and engines over it.

"Subordinate to the superintendent were one or more masters of transportation, according to distance operated, who were constantly moving over the road to see that the *employés* attended properly to their duties while out with the trains. At principal stations where locomotives were changed or kept in reserve, an engine-despatcher was stationed to see that the locomotives were in good order for service, that they were properly repaired and cleaned when at the station, to supervise and control the engineers and firemen, and to assign the requisite crews to engines.

"Maintenance of road and structures for each line was in charge of a superintendent of repairs, with the necessary supervisors, road-masters, foremen, &c.

"Maintenance of rolling-stock was in charge respectively of the master machinist, who managed repairs of locomotives, and the master of carpenters, under whose charge all repairs to cars were made.

"The above officers were independent of each other and reported directly to the general superintendent.

"The maximum force employed at any one time in the transportation department of the military division of the Mississippi was about 12,000 men."—(*a*).

*Construction Department.*

"The construction corps of the military division of the Mississippi was organised in six divisions under the general charge of the chief engineer, and at its maximum strength numbered nearly 5000 men. To give the corps entire mobility, enable it to move independently, and perform work at the same time at widely different points, each division was made a complete whole in itself, and equipped with tools, camp equippage and field transportation, in order that the whole, or any part of the same, might be moved at once in any direction where ordered, and by any mode of conveyance, by rail, with teams and waggons, or on foot."—(*a*).

*Details of Construction Department.*

"The following is the organisation of one division:

"Each division was under the command of a division engineer, and was divided into sub-divisions or sections. Each sub-division was under the immediate command of a supervisor. The two largest and most important sub-divisions in a division were the track-layers and bridge-builders. A sub-division was composed of gangs, each under a foreman. Gangs were sub-divided into squads, each squad under a sub-foreman.

"A division completely organised was composed of the following-named officers and number of men:

| | No. of men. | |
|---|---|---|
| Division Engineer ... ... | 1 | Staff. |
| Assistant Engineer ... ... | 1 | |
| Rodman ... ... ... | 1 | |
| Clerk ... ... ... | 1 | |
| Messengers ... ... ... | 2 | |
| | 6 | |

Sub-division, No. 1.

| | | |
|---|---|---|
| Supervisor of bridges and carpenters' work | 1 | Bridge builders. |
| Clerk and time keeper ... ... | 1 | |
| Commissary ... ... ... | 1 | |
| Quarter-Master ... ... | 1 | |
| Surgeon ... ... ... | 1 | |
| Hospital Steward ... ... | 1 | |
| Foremen (1 for each 50 men) ... | 6 | |
| Sub-foremen (1 for each 10 men) ... | 30 | |
| Mechanics and labourers... ... | 300 | |
| Blacksmith and helper... ... | 2 | |
| Cooks ... ... ... | 12 | |
| | 356 | |

Sub-division, No. 2.

| | | | |
|---|---|---|---|
| Supervisor of track | ... | 1 | Track layers. |
| Clerk and time keeper | ... | 1 | |
| Commissary ... | ... | 1 | |
| Quarter-Master | ... | 1 | |
| Surgeon ... | ... | 1 | |
| Hospital Steward | ... | 1 | |
| Foremen (1 for each 50 men) | ... | 6 | |
| Sub-foremen (1 for each 10 men) | ... | 30 | |
| Mechanics and labourers... | ... | 300 | |
| Blacksmith and helper ... | ... | 2 | |
| Cooks ... | ... | 12 | |
| | | 356 | |

Sub-division, No. 3.

| | | | |
|---|---|---|---|
| Supervisor of water stations | ... | 1 | Water supply. |
| Foreman ... | ... | 1 | |
| Mechanics and labourers... | ... | 12 | |
| Cook ... | ... | 1 | |
| | | 15 | |

Sub-division, No. 4.

| | | | |
|---|---|---|---|
| Supervisor of masonry ... | ... | 1 | Masons. |
| Foreman ... | ... | 1 | |
| Masons and helpers ... | ... | 10 | |
| Cook ... | ... | 1 | |
| | | 13 | |

Sub-division, No. 5.

| | | | |
|---|---|---|---|
| Foreman of ox brigade ... | ... | 1 | Teamsters. |
| Ox drivers ... | ... | 18 | |
| Cook ... | ... | 1 | |
| | | 20 | |

Train Crew.

| | | | |
|---|---|---|---|
| Conductors ... | ... | 2 | Train Crew. |
| Brakemen ... | ... | 4 | |
| Locomotive Engineers ... | ... | 2 | |
| Firemen ... | ... | 2 | |
| Cook ... | ... | 1 | |
| | | 11 | |
| Total ... | ... | 777 | —(*a*). |

*Italian Organisation.*

*Italy.*—"Each battalion of engineers in their army was to be augmented by a railway company, besides which, all the companies of engineers received a brief education in that kind of work * * * the corps of engineers actually work two small lines of railway. * * *

"The Italians * * * have detailed a body of officers of all arms of the service to study the organisation and execution of railways on the North Italian Railway."—(*a*).

The Italian Railway Engineer Company is composed of 5 officers and 205 men, when on a war footing: the engineers are divided into two regiments, to each of which two Railway Companies are attached.

The line taken by the Italian Government appears briefly to be:

To establish a central railway department to undertake the general direction of all military transport and instruction in railway service.

To form a special technical railway school at Turin, where practice is to be given in loading and unloading trains, plate laying, bridge making, &c.

Men who cannot be taught in the school will be trained on the neighbouring lines. Twelve officers are to be detailed annually to study railway organisation and report thereon, and prepare projects for improvement from the military point of view.

From the annual contingent of conscripts those who have been employed on railways will join the railway brigade.—(*a*).

*Proposed Military Railway Corps.*

It is proposed that the military department of a Railway Corps should be organised for the following duties:—

1. The rapid repair of lines of railway which have been damaged by the enemy.

2. The working of railways for the wants of the army in the vicinity of the enemy.

3. The construction of a military tramway, and the working of the same.

4. The demolition and crippling of lines in the possession of the enemy, or of those which it is necessary to abandon.

5. The management of loading and unloading trains containing troops of all arms, guns, wagons, &c.; the fitting up wagons as ambulances, and the repairs to rolling stock.

These duties cannot be done in time of war by civilians, and to carry them out effectively the Railway Corps should be exercised at them during peace, so that they will be effective from the first day of taking the field, and the men accustomed to work with the materials they will have to handle, and to drive the engines they will have to use.—(*b*).

*Details of Proposed Military Railway Corps.*

There should be at least 3 companies—2 service and 1 depôt—forming the Railway Corps to render it effective, and it is proposed to organise and equip them as follows :—

1 Lieut.-Col., R.E., Commandant of the Military Railway Corps, and engineer of all works constructed by it.

No. 1 (Steam Sapper) Company.

This company to be formed and equipped for the rapid repair of damaged lines, so as to render them an assistance to the army, and to work them with steam sappers as locomotives, until they are in a condition to be used with the ordinary rolling stock.

The work to be done will principally be making temporary bridges, erecting wire tramways, removing obstructions of rock, masonry, and earth, renewing and repairing permanent way, constructing deviations to avoid obstacles, and hauling trains up steep inclines.

The trades most suited for employment in carrying out these works are carpenters, masons, smiths, fitters, miners, and quarrymen, and in addition all the men of the company should be experienced platelayers, and well instructed in spar bridging.

The details of the company organisation would be as follows :—

1 major, R.E., commanding, specially qualified as a military railway engineer.

1 captain, R.E., with experience in mechanical engineering and bridging.

The company to be divided into 3 sections.

Section No. 1 (Platelaying Section).

Detail :—

| | | |
|---|---|---|
| 1 | Lieut., R.E. | |
| 7 | N.C.O. (foremen platelayers.) | |
| 10 | carpenters | Sappers. |
| 10 | masons or bricklayers | Sappers. |
| 2 | smiths | Sappers. |
| 6 | engine drivers and fitters | Sappers. |
| 20 | quarrymen and miners | Sappers. |
| 1 | telegraphist | Sappers. |
| 6 | clerks, batmen, cooks, bugler | Sappers. |
| 62 | | |

Equipment :—

2 steam sappers (with road and railway wheels) and 6 tenders, loaded with rails and sleepers (about 20 tons), 1 steam sapper (with road and railway wheels), and 3 tenders loaded with baggage of section, and tools, &c., as follows :—

1 steam rock drill (3 cwt.), for boring holes up to 4 ft. deep at about 9 inches per minute; useful in case of rock obstructions. One of the steam sappers should be specially fitted with a pipe to supply steam to it.
1 portable forge with anvil.
2 sets platelaying tools.
20 crowbars and jumpers.
2 boxes carpenters' tools (small).
1 box, smiths' " "
1 " fitters' " "
12 sledge hammers.
40 picks.
30 shovels.

Section No. 2 (Wire Tramway Section).

Detail :—

1 Lieut., R.E., specially conversant with wire tramways and spar bridging.
7 N.C.O. (carpenters, smiths, or fitters.)

| | | |
|---|---|---|
| 20 | carpenters | Sappers. |
| 6 | engine drivers and fitters | |
| 3 | smiths | |
| 20 | miners and quarrymen | |
| 6 | clerks, batman, cooks, bugler | |
| 62 | | |

Equipment :—

2 steam sappers (with road and railway wheels) with 6 tenders, loaded with wire rope, tramway wire, rope pulleys, &c. (about 20 tons), 1 steam sapper (road and railway wheels) and 3 tenders, loaded with baggage of section, tools, &c., as below. One of the steam sappers to be fitted with winding drum for haulage.

Tools, &c. :—

6 pit saws.
10 sets carpenters' tools (small).
2 " smiths' " "
1 " fitters' " "
1 " platelayers' " "

12 crowbars.
40 picks.
30 shovels.
10 cut rope and lashings.
2 portable forges with anvil.

Section No. 3 (Bridging Section).

Detail :—

1 Lieut., R.E., specially skilled in military railway bridges.
7 N.C.O. (carpenters or smiths.)

| | |
|---|---|
| 20 carpenters | Sappers. |
| 4 smiths | |
| 6 fitters or engine drivers | |
| 6 masons | |
| 14 miners or quarrymen | |
| 5 clerks, cooks, batmen, &c. | |
| 62 | |

Equipment :—

1 steam sapper (with road and railway wheels) as crane engine, with 3 tenders.

1 steam sapper, spare as a reserve (with road and railway wheels), and 3 tenders.

1 steam sapper loaded with baggage of section and tools, &c., as follows :—

3 portable forges with 2 anvils.
10 pit and cross-cut saws.
10 sets carpenters' tools (small).
1 set fitters' " "
2 sets smiths' " "
12 sledge hammers.
12 crowbars and jumpers
1 set platelaying tools.
40 picks.
30 shovels.
10 cwt. rope and lashings.
10 cwt. bolt iron spikes, &c.

No. 2 (Tramway) Company.

The duties allotted to this company will be the construction and working of a military line of railway, and also the same work as allotted to the first company; but it is proposed specially to train the men to work light tank engines, and to provide a greater number of the special artificers who are required for carrying on the traffic of a railway, and for the repair of the rolling stock.

The details of the company organisation would be as follows:—

1 Major, R.E., commanding, specially qualified as a railway engineer.

1 Captain, R.E., conversant with the duties required from a traffic manager.

Section No. 1 (Bridging Section).

1 Lieut., R.E., skilled in bridging and laying out a line of railway.
7 N.C.O. (carpenters, smiths, or masons.)

| | | |
|---|---|---|
| 20 | carpenters | Sappers. |
| 4 | smiths | |
| 3 | engine drivers or fitters | |
| 10 | masons or bricklayers | |
| 12 | miners or quarrymen | |
| 6 | batmen, clerk, bugler, &c. | |
| 62 | | |

Equipment:—

1 steam sapper (with road and railway wheels) and 3 tenders, loaded with baggage of section, stores, and tools, &c., as follows:—

2 portable forges with anvil.
10 sets carpenters' tools (small).
1 set fitters' " "
2 sets smiths' " "
12 sledge hammers.
10 pit and cross-cut saws.
12 crowbars.
1 set platelaying tools.
40 picks.
30 shovels.

Section No. 2 (Platelaying).

Detail:—

1 Lieut., R.E., skilled in laying out railway curves.
7 N.C.O. (carpenters, smiths, masons, or fitters, foremen platelayers.)

| | | |
|---|---|---|
| 6 | carpenters | Sappers. |
| 3 | engine drivers (smiths or fitters) | |
| 10 | masons or bricklayers | |
| 31 | miners or quarrymen | |
| 5 | clerk, cook, batmen, &c. | |
| 62 | | |

Equipment :—

1 steam sapper (with road and railway wheels) and 3 tenders, loaded with baggage of section, stores and tools, &c., as follows :—

1 portable forge.
3 sets carpenters' tools.
2 „ platelayers' „
1 „ smiths' „
6 sledge hammers.
12 crowbars.
40 picks.
30 shovels.

Section No. 3 (Working Line).

Detail :—

1 Lieut., R.E., with knowledge of mechanical engineering and experience of workshops.
7 N.C.O. (foremen, carpenters, smiths or fitters.)

| | |
|---|---|
| 15 carpenters | Sappers. |
| 12 engine drivers and fitters | |
| 4 smiths | |
| 6 telegraphists | |
| 12 guards (for military trains) | |
| 3 clerks and storekeepers | |
| 3 cooks, bugler, &c. | |
| 62 | |

Equipment :—

1 steam sapper (with road and railway wheels), and 3 tenders loaded with baggage, tools, &c., as follows :—

3 portable forges.
10 sets carpenters' tools.
3 „ smiths' „
3 „ fitters' „
1 set platelayers' tools.
40 picks.
30 shovels.

The carriage provided by the steam sappers for this company is considerably in excess of the amount required for the conveyance of baggage and stores, but it is intended that the engines should be available for general work on the line, bringing up rails, sleepers or timber, or if not employed in this manner used as transport for the army. One of the steam sappers should be fitted up as a crane engine.*

The 3rd or depôt company needs no notice, its object being to keep up the supply of skilled men for the other two, they should be carefully trained, especially in platelaying, engine driving and spar bridging.—(*b*).

*Special Tools for a Railway Corps.*

The special tools required for railway service are not numerous, and can easily be made if the numbers are deficient; perhaps the only exception is the "jim-crow" or rail-presser. For military railway work their strength should be in excess of ordinary requirements. * * * *

A heavy screw press, and rail-punching machine, fitted so as to run on light trolly wheels, would be of great use in cases where a broken rail has to be replaced; the ends could be cut and trimmed, punched on the spot, and united by fish plates.—(*a*).

*General Scheme of Responsibility.*

The general scheme seems to be of this nature, laid down in a descending order:—

1. The Commander-in-Chief.
2. Officer in charge of communications.
3. Officer in charge of railways, as part of communications, working together with civil officials of railway companies, and also assisted by general staff.
4. Officers as railway managers over new railways, or those disorganised.
5. Or as giving military assistance to civil managers.
6. Railway station-masters, either supreme or assisting the civil official.
7. Railway battalion for independent railway service.—(*a*).

*Jacqmin's Opinion.*

In concluding his remark upon the use of railways, in the war of 1870-1, M. Jacqmin lays down as the second of two leading ideas governing the successful employment of railways in war, the "association of the military and technical elements."—(*a*).

* When travelling by road, except over very good and flat country, the steam sappers will not be able to take the 3rd wagon with them, but, as it is required when working along a line of rail, a second trip should be made to bring it up.

## Section 12. Necessity of Practice in Time of Peace.

*Three Conditions of Warfare for Great Britain.*

The circumstances in which Great Britain may be involved in war so as to make the question of railways one of importance, are:—

1st. In defence against a successful invasion.

2nd. As an ally of a European or other civilized power possessing a railway system, as, for instance, Belgium.

3rd. With an uncivilized power, without railways, as in Abyssinia.—(*a*).

*Means of obtaining Practice in Working Railways in Peace Time.*

There appear to be three methods by which this difficulty might be overcome.

1. The Government to construct by "construction" companies, and manage with "working" companies, a short line of railway, of general utility for private traffic, or of special use, as uniting the different forts of one of the great intrenched camps; the advantages of such a scheme would be improvements in defence of the place selected, and a permanent school of instruction; the disadvantage would be the expense, which would be probably very serious.

2. The Government to take over an existing line, and manage it by "working" companies, arranging by contract with the Railway Company, to whom it originally belonged, for its management in time of war, as recommended by Major-General Sir G. Wolseley. This would not be so expensive as the first scheme, and probably as efficacious for purposes of training, but it would be attended with considerable difficulties, more particularly at the outset. It might, however, be done by degrees, by the gradual substitution of military for civil *employés*.

3. Following the example of the Austrians and Italians, the "working" companies might be attached in peace to some of the Railway Companies, by whom they would be trained in their several duties. —(*a*).

*Importance of Practice in Peace Time.*

Proficiency can only be obtained by organisation and practice, and until preparations are made in peace time to provide suitable materials, and to practice men at the work of repairing and laying railways,* it will be impossible to expect rapid progress in time of

* It is not enough to show a recruit how a line ought to be laid, and give him a few days instructions at platelaying. Railway companies should be continually employed at railway work, and learn to work together in gangs or sections.

war, on a military line, when men will have to learn the work they should be proficient at. In such a case the work will probably be a drag on the available labour of the enemy without giving an adequate return for that expended in it. Officers and men will only work in a half-hearted way, when they see the inutility of the work upon which they are engaged.—(*b*).

*Systems of Effecting Practice in Germany and Russia.*

We pass on now to the *junior officers* and *men* of the railway corps. In time of *peace* they must have continual practice in destroying, repairing, and working of railways (especially the latter), and the question is how to get it. There are two chief methods, the German and the Russian. In the former, the men are employed on many private as well as State railways in repairing bridges, enlarging stations, laying down fresh rails, &c. They also (chiefly for the purpose of instruction) formed, in 1875, a line of their own from Berlin to Zossen (30 miles), of which they have the entire management. The distinctive feature of this system, as we understand it, is the keeping up the military organisation throughout; even on private lines, the men are always together as a military railway section, company, &c., engaged for a time on some special work, making a tunnel, repairing a bridge after inundation, or whatever it may be. In Russia, on the contrary, the men are dispersed among the different railway companies, and are (for the time being) under the directors of those companies. A sort of semi-military organisation is, however, kept up by the special officers charged with the transport of troops. They form a connecting link between the military authorities and the railway companies in all that concerns the men under the latter, and are to some extent responsible for them.

Which is the better of these methods is somewhat doubtful, the German is less complicated, and keeps up more military discipline, but on the other hand the men are not always sure of employment, unless they have special lines of their own. On the whole, however, we are inclined to prefer it to the Russian plan.—(*c*).

*Recapitulation of Proposals.*

To give them effect it seems desirable—

1. To establish a regular system of communications as a branch of the Quarter-Master-General's Department, by which rules to govern all transport operations should be drawn up.

It would probably not be thought necessary to enter into the elaborate detail of the German Etappen, but some definite rules should be drawn out for the guidance of the officers in charge of communications, field railways, stations, &c.

2. A railway corps should be formed of (1) officers to be trained as railway managers, working in concert with the civil managers of existing lines, and (2), a railway battalion, or nucleus thereof for independent service.

3. Troops should be trained in all duties connected with embarkation and disembarkation of guns, stores, &c., and in improvising methods of doing this without the ordinary convenience of platforms. This should be a regular portion of their instruction, as much as any part of the Field Exercise.

To effect this, the War Department should have the use of one or more stations with trucks.

4. Officers should be detailed to report on the various railways as to their military capacities, and prepare projects for their defence and adaptation to military requirements.

5. The railway companies should be invited to assist in the general work, by preparing military time-tables, by intercalating military trains to be run at need, and in concert with the military authorities carrying out, as far as possible, such modifications in their rolling stock as will render them more adapted for use in war.

At the close of his remarks, Jacqmin observes—"the education of our country is yet to be formed in military railway transport, and the employment of railways in war." How stands the case with us? Are we educated, or too indifferent to the experience gained so hardly by others to learn ourselves?—(*a*).

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