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ERRATUM.

In page 1, line 6, of the January, 1907, number the words "(the late)" should be omitted.

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SUGGESTIONS FOR THE EMPLOYMENT OF R.E. FIELD COMPANIES DURING FIELD TRAINING AND MANŒUVRES.

By BT. COL. J. L. IRVINE, R.E.

THE employment of Royal Engineers during field operations should approximate as nearly as possible to their duties on active service.

For R.E. Field Companies these may be divided into three heads:—

1. Duties on the Line of March.
2. „ in Camp or Bivouac.
3. „ in Attack or Defence.

DUTIES ON THE LINE OF MARCH.

1. Under the first category may be included the following:—

(*a*). *During an Advance.*

Clearing obstacles or roads, through woods, etc.
Bridging streams, rivers, ravines.
Repairing bridges.
Constructing and repairing roads; making roads across swamps or bogs.
Improving communication generally.
Repairing railways, clearing tunnels.
Improving fords.
Arranging temporary water supply.

(*b*). *During a Retreat.*

Creating obstacles to a pursuit, such as felling trees (by tools or explosives) across roads, tracks, etc.
Making wire entanglements.
Digging pits.
Destroying bridges and culverts.
Obstructing fords.
Flooding low-lying ground by damming streams.
Laying mines and fougasses.
Blowing in or blocking tunnels.
Destroying railways and telegraphs.
Arranging temporary water supply.

DUTIES IN CAMP.

2. The principal duty of R.E. in camp is water supply. This may include :—

Arrangement of temporary water supply by hand or steam pumps.
Storage of water.
Construction of filters.
Distribution of water in a permanent camp by laying lines of pipes and erecting standpipes.

Other duties include :—

Construction of roads and paths.
Improving drinking and washing places.
Improving fords.
Constructing huts and shelters.

Also, in a camp of a permanent nature :—

Constructing hospitals, remount depôts, latrines, cemeteries, etc.

DUTIES IN ATTACK AND DEFENCE.

3. (*a*). In *Attack* the R.E. would be employed in :—

Removing obstacles.
Blowing in gates and doors.
Blowing up walls and stockades.
Entrenching important points, such as hills, defiles, villages, and farms seized during the attack.
Removing mines.
Constructing counter-mines.
Erecting obstacles or defence works to provide against a counter-attack.

(*b*). In *Defence* :—

Blocking roads and approaches.
Destroying bridges and culverts.
Superintending clearance of woods.
Clearing field of fire.
Constructing obstacles, alarms, and flares.
Laying mines.
Measuring ranges.
Constructing defences and posts on specially important points.
Constructing and superintending construction of field defences.
Improving internal communications.
Preparing the way for a counter-attack by removing obstacles.
Arranging water supply.
Laying tram lines.
Sanitary and hospital services.

(*c*). In case of *Sieges* the general arrangement and construction of siege works both in attack and defence.

From the above it will be seen that the duties of Royal Engineers in war time are usually of a constructive or destructive nature, which are in most cases impossible to carry out during peace manœuvres. But a great deal can be done by arranging for the R.E. company to theoretically carry out constructive or destructive work by means of reports and drawings.

It is rare in peace manœuvres that a force retiring or advancing will take notice of such small features as a bridge or culvert over a stream, one of the reasons usually given being that to carry out the demolition or reconstruction would delay the remainder of the troops too much; but a broken bridge or culvert is of considerable importance in actual warfare and cannot be neglected. The demolition could be theoretically carried out by detailing the actual R.E. and infantry party (with covering party if necessary) for the work and sending them off to the site; the O.C. would then draw up his scheme, make up dummy charges and actually fire them, and on completion leave a notice stating the hour at which the demolition was carried out and the nature of the damage done.

The demolition party could then rejoin the remainder of the force, which in the meantime would have continued its march; and the O.C.R.E., on the termination of the manœuvre, would hand in to the umpires his report of the demolition, with drawings, details of charges, etc.

Similarly, if the attacking force found its advance blocked by a broken bridge, etc., the R.E., with working and covering parties, could be sent forward and the work could be arranged by the R.E. without stopping the remainder of the force.

The report and drawings would show the work done, the umpires would be able to criticise them just as well as if the reconstruction had actually taken place, and the R.E. would have had useful practice.

Attached are two memos on the subject, giving further examples of work that would be possible, which have been issued at Aldershot for the guidance of R.E. field units.

It is too frequently the practice during field operations to employ the R.E. solely on water supply arrangements when in camp, and during actual manœuvres to leave them in reserve or to employ them in laying out or digging trenches on some hill well in rear of the line of operations. As the R.E. company on service would probably number few more than 100 rifles the amount of entrenchment they could do would not be great, and in actual warfare the duty of entrenching must fall to the infantry, with or without R.E. superintendence. It is therefore wrong to employ R.E. during peace manœuvres on entrenching a useless piece of ground.

During field operations useful instruction could be given by detailing R.E., with the necessary covering and working parties of infantry, to carry out *theoretically* such duties as the following, reports and drawings of the work done being furnished to the umpires in each case :—

Demolition and reconstruction of bridges, culverts, railway tunnels, etc.

Construction and removal of obstacles on roads or in front of a position.

Clearing field of fire.

Entrenching or preparing for defence specially important points (such as a village, farm, or hill) in, or in rear of, the main line, which may be useful as rallying points or *points d'appui.*

Temporary water arrangements.

Actual work may sometimes be done in improving a line of approach for wagons across boggy or marshy ground, improving drifts or watering places, constructing temporary pontoon, trestle, or spar bridges. In the case of a skeleton enemy it would be an advantage to have a R.E. officer and a few men with it to arrange demolitions, etc.

Should the proposed organization (2 Field Companies to a Division, under a senior officer as O.C.R.E.) be approved, the O.C.R.E. should in all cases accompany the Division during Divisional and Army Corps Training; and he would be able to advise as to the most suitable employment of the R.E. Companies under the circumstances.

ARRANGEMENTS FOR EMPLOYMENT OF ROYAL ENGINEERS DURING WINTER MONTHS.

TECHNICAL WORK.

1. One unit will be detailed weekly for a march out and technical day under its O.C. A scheme will be prepared by the O.C. unit and a copy will be forwarded to the Orderly Room by 12 noon the previous day. A report on the work carried out will be forwarded to the O.C.R.E. on the following day.

2. The following schemes are suggested :—

Selection of position for brigade or division on previously unreconnoitred ground.

Destruction of railways, including demolition of bridges, tunnels, etc., or flooding of railway on low-lying ground.

Hasty watering arrangements for a division or brigade of cavalry.

Clearing woods, etc. (probably actual clearing of brushwood and felling timber could be carried out by arrangement with the C.R.E. Lands).

Defence of villages and houses.

3. In carrying out these technical schemes every effort will be made to make the work as realistic as possible.

For instance :—

(*a*). In carrying out demolitions the O.C. unit should tell off a party for the work with the necessary tools, and the officer in command of the party will set to work in as practical a manner as possible.

He will carefully consider the nature of the demolitions to be carried out, make up a dummy charge, place it in position, fix a detonator, and actually fire it. He will make a rough sketch of the object of destruction, giving accurate dimensions, calculate out the charge, and show in his sketch and report how he actually proposes to hold the charge in position and the expected effect of the explosion.

(*b*). In preparing a house or village for defence, the officer should make a sketch of the works he proposes, give details of working parties, list of tools, time required for completion ; and should not undertake, or assume that he can carry out, work for which he has neither men or tools.

(*c*). In repairing bridges he should only make use of the tools and materials available, and should state in his report from whence the material is obtained.

(*d*). If he is required to build redoubts or field works, and he is not allowed to break ground, he will design and trace out the work, lay out tools, and extend his men in their actual position for work.

He should only construct obstacles for which he has time and materials.

4. The mounted portions of units should, as far as possible, take part in the general scheme, or, if this is not feasible, opportunity should be taken for instruction in driving drill and reconnaissance work.

5. The unit detailed for technical work will arrange for dinners to be taken out and cooked, or for supply of soup, etc.

INSTRUCTIONS FOR R.E. UNITS WHEN EMPLOYED IN FIELD OPERATIONS.

1. When R.E. Units are employed in field operations, and are detailed to carry out duties which it is impracticable to perform in peace, but which would be necessary in war, they will use every effort to make the work as realistic as possible.

2. For instance, in carrying out demolitions the O.C. unit should tell off a party for the work with the necessary tools, and the officer in command of the party will set to work in as practical a manner as possible.

He will carefully consider the nature of the demolitions to be carried out, make up a dummy charge, place it in position, fix a detonator, and actually fire it.

He will make a rough sketch of the object of destruction, giving accurate dimensions, calculate out the charge, and show in his sketch and report how he actually proposes to hold the charge in position and the expected effect of the explosion.

He will, if asked for it, hand in the sketch and report to the umpire, or, failing this, will send it in to the Orderly Room on return to barracks.

3. In preparing a house or village for defence, he should make a sketch of the works he proposes, give details of working parties, list of tools, time required for completion; and should not undertake, or assume that he can carry out, work for which he has neither men nor tools.

4. In repairing bridges he should only make use of the tools and materials available, and should state in his report from where the material is obtained.

5. If he is required to build redoubts or field works, and he is not allowed to break ground, he will design and trace out the work, lay out tools, and extend his men in their actual position for work.

He should only construct obstacles for which he has time and materials.

6. If required to defend a position in conjunction with infantry, the R.E. would probably be employed on the more technical parts of the defence, the infantry, unassisted, carrying out the actual trench work.

But if, during field operations, the G.O.C. under whom they are employed should wish the R.E. to combine with the infantry in digging entrenchments, the most suitable way of employing the sappers would be to dig short lengths of trench, at intervals between the infantry parties, which would serve as a pattern to the other troops.

7. It is probable, however, that R.E. would not be employed in actual trench work, and they might then be usefully occupied in constructing obstacles in suitable positions, clearing the field of fire, arranging communications, etc.

8. In wooded country the operation of clearing the field of fire is a very difficult one, and in making calculations officers are apt to be too sanguine as to the pace at which it can be done.

When trees are felled they must be dragged or carted away, as their leaves, branches, and trunks afford both concealment and cover to the enemy.

In making hasty clearings it would probably be better to lop and burn the lower branches, and only to fell trees where it is desired to block roads or other lines of approach.

THE ECONOMY OF COAST DEFENCE.

By Col. S. A. E. Hickson, D.S.O., R.E.

We have been told by the Navy that fortifications, submarine mines, and fixed defences generally are, for the most part, useless and expensive luxuries. Is there not good reason, just at the present time, to enquire why a separate Coast Defence Service has been called into existence. Why has a new name been given to what at present are merely the harbour defences of our naval bases, and are strictly speaking not an organised system for the Coast Defence of our Island Fortress? Is not an organised system possible on entirely new lines, especially suited to the characteristics of our country and people?

The sphere of the Navy is understood to be free and unfettered action at sea; likewise the sphere of the Army is understood to be free and unfettered action on land. The sphere of Coast Defence then I conclude to be to keep touch between the Navy at sea and the Army on land, by watch and ward along our shores. Acting along our coasts as the best possible line of resistance to the enemy, and protecting the shores, ports, and commercial towns of the mother country against surprise raids, Coast Defence should set our Navy absolutely free for action on the sea and our Field Army free for service abroad, by defying disembarkation.

This at least would seem to be the natural conclusion to be deduced from the contest which has once more been raging as to the functions and sphere of action of the Navy, and which has ended in a way so satisfactory to most people. That is to say the knell of the "dinghy school" has been *tolled*. To paraphrase a famous pun, it has been *told* that it is not credited; it has been ding-donged out of existence. The primary duty of the Navy, we are now distinctly informed, is to keep open our communications and look out for being strong at the essential strategic point, rather than to prevent raids. The air has thus been cleared; and I would invite those who would clear their brains on this matter to study with care both the recent lucid and instructive articles of Sir Cyprian Bridge (see *Morning Post*) and still more the very able expositions of Capt. Slade, R.N., of the Naval College. The lecture by the latter, published in the *R.E. Journal* of April, 1906, is well worth reading with the greatest care line by line. I have done so myself and have had the further great advantage of attending some of his lectures at the Naval War Course at Plymouth.

Whether we study Capt. Slade or Sir Cyprian Bridge (who writes as representing the Blue Water School) or other naval experts, all alike seem now agreed. The Navy cannot guarantee the prevention of raids. Even raids in considerable force may be made by troops numbering, possibly, even 20,000 or 30,000 men. Sir Cyprian especially tells us that, outside the dinghy school "no one asserts or ever has asserted that raids in moderate strength are not possible even in the face of a strong defending Navy.* It is a fact that the whole of our policy for many generations has been based upon an admission of their possibility." Capt. Slade tells us, even still more plainly, that raids cannot be prevented, though he seems to have in view raids of somewhat more modest dimensions. But if the Navy cannot prevent raids who is to do so, if it be not our Coast Service? What a warning is here held up to the, meantime, slumbering and unconscious inhabitants of our coast!

Where is our organised system of Coast Defence, and how are we to begin to construct it?

We have no desire to trespass upon the sphere and functions of the Navy, which is, of course, and must always remain our first line of defence, keeping open our communications and keeping in view the main strategical objective of the moment. This may, however, take our fleets away from our shores, and an opportunity for a raid may then be given. Even though such a raid should not actually occur, if distant strategical operations render necessary the absence of our fleet, in such a case (as Lord Rosebery asks) will the inhabitants of our commercial ports and coast cities be content to remain at home, and there receive a prospective visit from several thousand foreign visitors? Will they not rather desire to receive them at the muzzle of their own guns? This being so, in what manner and by what means should our Coast Defence be conducted. Let us endeavour to ascertain where its duties begin and where they end?

Elaborate land fortifications or coast defences are, I believe, rightly doomed as far as this country is concerned, notwithstanding the experience of Port Arthur. Powerful and costly works, with deep ditches, escarp and counterscarp galleries, and caponières, exceeding even modern battleships in cost, are in our case no longer necessary. On the other hand the development in range and accuracy of artillery fire during the last ten years has been prodigious. Heavy guns mounted on land can to-day altogether defy battleships. "The effective range of well-placed heavy guns against ships may be taken as about 15,000 yards" (see Capt. Slade's article in *R.E. Journal*). Capt. Slade further tells us that it is not necessary to have very many of these guns but that there should be sufficient to make the risk to

* We have the well-known instance of Buonaparte escaping from Toulon under the very nose of Nelson.

the enemy very considerable. We know also that, at one of the earlier bombardments of Port Arthur by the Japanese fleet, on March 10th, 1904, when one of their battleships exposed itself for a few minutes to the fire of one of the Russian forts, at a range of 12,000 yards, so hot was the fire that the vessel in question rapidly sought the shelter of the cliffs from which she had emerged; the next shot would probably have sunk her. Their ships preferred even to keep outside 20,000 yards.

Thus we know very distinctly how greatly ships fear modern heavy guns mounted on fixed defences. The one thing Admiral Togo learnt to be careful about was to keep his ships outside the range of the guns of Port Arthur. Has, however, full justice yet been done to the economic value of the range and accuracy of such guns? Have we yet correctly gauged the full importance of the great fear that modern battleships have of them; and the consequently great part they may yet have to play in Coast Defence? Again, in the rapid fire and accuracy of heavy field guns and of machine guns, have we not other formidable weapons to be placed, wherever full command of view and range permit, so that the greatest advantage may be taken of their power—as can be done when firing out to sea.

Guns mounted on land possess this further enormous advantage over guns mounted on ships, that they can attack anything coming within their range without any reasonable fear of effective counter-attack or, if carefully concealed, of revealing their own position. Nor have they anything to fear either from tempests, mines, or torpedoes. It is then to the artillery that we must turn as the basis of our organisation for Coast Defence.

Let us inquire next how Naval experts themselves suggest that we on land should guard against raids or surprise disembarkations on our shores. They first lay it down as an axiom, and in this we all concur, that the men on land must be in their positions *before* the enemy's ships are sighted on the horizon. "It will be too late to get the men to their stations if we wait *until* the ships are sighted. Within an hour of that time it would be quite possible for a covering force to land. Every effort must be made to prevent a disembarkation taking place unopposed; a very small number of men properly placed, even if only behind hedges and walls, would be quite enough to make it a work of very great difficulty and danger."* The enemy, we are further told, will attempt to land in some part of the coast *clear of the fixed defences*.

It is manifest from this line of argument that to successfully counteract the conditions favourable to disembarkation, either we must in times of emergency have infantry at all times ready behind walls and hedges along the intervals between our defended ports, or

* Capt. Slade's article, *R.E. Journal*, April, 1906.

we must extend our lines of batteries on the flanks of those ports until they meet, the intervals between ports being thus guarded by land batteries. Seeing the range, accuracy, and rapidity of modern heavy guns, field artillery, machine guns, and magazine rifles, is not the latter the better alternative, since the former course is practically impossible? That is the question I have to ask.

In endeavouring to reply fully I will first observe that it follows from what has gone before that,

(1). It is the duty of the Navy, as our 1st Line, if strategically possible, to prevent altogether both raids and invasion.

(2). It is the duty of the Coast Defence, if a raid gets past the Navy, to prevent a successful disembarkation.

The question is how is this latter duty to be most efficiently and economically performed?

We are in search of a system of Coast Defence particularly suited to the characteristics of our native land, which are very marked and peculiar. We wish to cease mere imitation and to commence artistic construction. England, as distinguished from most foreign countries, whose military affairs we have sometimes been too prone merely to imitate, may be described as being a small island with many ports and full of large towns. The result is that those towns are very close together, not only inland but along our shores, and more especially along our southern coast where large cities and commercial ports are separated by very small intervals.

From the Nore to the Lizard may be taken as 400 miles; and along this space there exist already seven more or less defended ports, so that the average distance between them is but 57 miles or thereabouts. As the range of heavy guns is 15,000 yards it now suffices to place heavy gun batteries 10 miles apart; so that only 5 such batteries would be required to each average interval. I am aware that the length and danger of the intervals varies considerably, that between Portland and Plymouth being the greatest, and that from Dover to Newhaven the most exposed; but I estimate, as I shall show, that 36 heavy (9·2″) batteries would suffice. These, of course, would not be placed at uniform intervals of 10 miles, but would be grouped, being nearer or farther apart according to the dangers of the coast. Similarly each heavy battery would consist of say 3, 2, or even 1 gun, according to circumstances. Attached to each of these heavy batteries, which by reason of the great size of their guns must be fixed, there would be movable batteries of 5″ or 4″ guns, 15 prs., and machine guns in plenty.* All men, more especially those in reserve, would further be armed with magazine rifles.

* Each 5″ heavy battery could defend 10 miles against a landing from transports by day.

Such is the system now presented for consideration, particularly by those whose homes and property are situated on our coasts. With an organisation based on this method every important anchorage would be defended and watched, at, as I shall presently show, a minimum cost and with maximum efficiency, no surprise raid or disembarkation being possible. Every range would be marked and known, and lit up, and emplacements prepared for movable armament and electric lights in the intervals. Thus, even if a temporary landing were effected in a fog or by night, destruction would await the raiders on the weather clearing.

Under the old system the plan was to surround our naval bases by a ring of forts. This plan has been abandoned; but there is still a tendency to deploy considerable garrisons round our defended ports and employ our heavy movable batteries in their immediate neighbourhood for what is called defence against land attacks. Having regard to the characteristics of our island fortress this appears to me a mistake in tactics. *A land attack should be made impossible.* For us the place to meet the enemy, the place to take him at a disadvantage, is during disembarkation in the curtains between our defended ports. If we once allow him to land and to march to the attack of our defended ports on their land side, we forfeit forthwith all the advantage of long range artillery fire. Inland, in our undulating country, it is impossible for us to get this, whilst we at the same time offer the enemy on land all the advantages of cover which it is impossible for him to get at sea. Heavy guns, on the sea coast, are so placed as to get the greatest possible advantages which they can confer. They have there the greatest possible field alike of fire and of view; whilst, properly supported by smaller pieces of artillery, machine guns, electric lights, and rifles, they are practically immune from attack by sea. I may be wrong, but it does not seem to me that there can be any doubt upon this point; *the enemy must not be permitted to land, be he raider or invader.*

Occasional heavy fixed batteries, with movable artillery, machine guns, etc., to move up rapidly between them, is the suggestion. To see how the scheme works out in detail requires reference to the map and a knowledge of our coast. But, even omitting the fixed batteries, and merely dividing our coast into sections, here at any rate is a principle and a definite system of Coast Defence based on it; namely absolutely to defy and defeat raids before or during disembarkation, mainly by artillery skilfully placed in selected positions on our coast—rather than to permit the enemy to land, and then suffer a siege or land attack, affording him all the advantages of cover of which the sea deprives him. The strength and efficiency of such a scheme it seems in every way desirable to consider,—or find a better.

I will now discuss the economy of the scheme, so important in time of peace, bearing in mind that every fully-fledged battleship costs now nearly two million pounds sterling. The data, which I have so far been able to get, may not be altogether reliable, so are subject to modification, but I have tried to err on the side of excessive cost. As already stated I take the Southern Coast, from the Nore to the Lizard, as an example, and the number of heavy batteries there required I estimate at 36. Taking into consideration such places as the Goodwin Sands and other areas of difficult navigation, this is no doubt considerably in excess of actual necessity. I place the batteries roughly as under :—

Sheerness to Dover	4
Dover to Newhaven	7
Newhaven to Selsea Bill	5
Swanage to Portland	3
Portland to Plymouth	11*
Plymouth to Falmouth	4
Falmouth to Lizard	2
Total heavy batteries of one to three 9·2″ guns each ...	36

Assuming that there is allotted to each heavy fixed battery station, to fill the average interval of 10 miles between it and the next,

1 battery of four 5″ or 4″ guns,
2 batteries of four 15-pr. do.,
4 batteries of six machine do.,

then the total cost will be :—

36 9·2″	batteries	@ £60,000	£2,160,000
36 5″ (or 4″)	do.	@ £12,000	432,000
72 15-pr.	do.	@ £6,000	432,000
144 machine	do.	@ £2,000	288,000
			3,312,000
Alternative emplacements, hut barracks, and electric lights			688,000
		Total	£4,000,000

Thus, to tie costly battleships to our shores, or in any way hold them directly responsible for the defence of our coasts against raids, is, it seems, a costly extravagance; since for a prime cost of £4,000,000, *i.e.* little more than the cost of two such ships, our southern coasts, the commerce of which is increasing so rapidly, might be made secure. The Navy might then be set free from all anxiety concerning them, to perform its own functions with its

* Eight would probably suffice, or even six.

strategy undistracted by thoughts of our coasts. Would not such a system conduce materially to the peace of mind of our inhabitants? The Navy tell us they cannot guarantee to prevent raids—they may be miles away; and the recent surprise raid of the Japanese at Chemulpo, before the declaration of war had reached that place, is for ever held up to us as a warning. We have in addition the recent American experience and the anxiety in the United States during the Spanish-American War. Finally, we have the experience of our own history a century ago; though long peace and a very poor acquaintance with the past have lulled the present inhabitants of our coasts into forgetfulness or ignorance of the events of those days.

The history of that period, however, and the whole sequence of events bearing upon the question of defence in the early years of last century, including the first formation of Volunteer corps, warn us plainly of the inevitable agitation and alarm which arise in times of national danger. Thus, referring to the difficulties that Lord St. Vincent and Nelson had to deal with in this respect, Capt. Mahan tells us that "The trouble for them undoubtedly was that which overloads, and so nullifies, all schemes for coast defence resting upon popular outcry, which demands outward and visible protection for every point, and assurance that people at war shall be guarded." With regard, however, to this dictum, given some years ago, we have to consider the fact that history has also shown repeatedly that Governments cannot resist this cry. The Chemulpo incident further shows that to-day there is more call than ever for vigilance. And finally, is it not the part of strategy (as Capt. Slade suggests) to consider the inevitable effect of such outcries? For convenience, therefore, I will briefly give the sequence of events as they occurred a century ago.

1801.—Nelson placed in command of a "Squadron of Particular Service" for the defence of the coast of England against invasion. "His presence in charge of the dispositions for defence only could quiet the public mind." He organises a flotilla and proposes Stationary Floating Batteries. Yet disdains mere defensive measures, and is more inclined "to keep the enemy as far from our coasts as possible and be able to attack them the moment they come out."*

1802 to 1805.—Fortifications, Martello towers, the Hythe military canal taken in hand by Pitt to allay the public mind. The Volunteers first formed and compulsory Militia Ballot enforced.

1805.—Nelson and his fleet thousands of miles away from our coasts in pursuit of the French.

* Mahan's *Life of Nelson*.

Whatever might have been correct strategy, our Government at that time was compelled to defend our coasts at extravagant cost. This may not have been wise or good strategy then; but would it not be both good tactics and politic to-day to take full advantage of the economic and defensive power of modern weapons which did not before exist.

Yet, whatever be our system of defence, it is neither guns nor ships nor machines of any sort which in the end decide the fate of nations; it is *the training of the men.* It must never be our tendency to place too much faith merely in building ships or in mounting guns. Ships must be handled with skill, and guns must be fired with accuracy, and the men themselves must be ably commanded. Russia, with all her vast resources, had to succumb to Japan, because the Japanese were better trained and better prepared, and had in every way better calculated the risks they intended to incur. We ourselves, only very recently, barely escaped succumbing to a very small power indeed, because we had under-calculated our difficulties. Should we not then endeavour to calculate with care, and be prepared to face the dangers to which our coasts would now be exposed in time of war under modern conditions.

How keenly at times Nelson's experience of a hundred years ago reminds us to-day that the old state of affairs is still existing, since, to all appearances, Englishmen are still reluctant to obey the demands of the times on their service. Capt. Mahan tells us that when, a century ago, Nelson "issued a proclamation to the Fencibles assuring them that the French undoubtedly intended an invasion, that their services were absolutely required at once on board the defence ships," only 385 out of 2,600 volunteered. Is Nelson's remark surprising that "They are no more willing to give up their occupations than their superiors."

It is strange how closely this remark coincides with the experience which Washington had recorded not many years earlier. Indeed, few things in history seem to me more sad and solemn than the picture of himself, drawn by the great American patriot, as he sat down, in the depth of the night, to indite to Congress a general impeachment of the principle of mere volunteering under the influence of patriotism as a basis for military service. "From the hours allotted to sleep," he says, "I will borrow a few moments to convey my thoughts on sundry important matters to Congress. I shall give them with that sincerity which ought to characterise a man of candour, and with the freedom which may be used in giving useful information, without incurring the imputation of presumption."* After a few preliminary remarks he thus expatiates on patriotism as a hopelessly broken reed on which to lean. "When men are irritated and their

* From a semi-official history published in 1805.

passions inflamed, they fly hastily and cheerfully to arms; * but after the first emotions are over, to expect, among such people as form the bulk of the army, that they are influenced by any other principles than those of interest, is to look for what never did and, I fear, never will happen; the Congress will deceive themselves, therefore, if they expect it. A soldier, reasoned with upon the goodness of the cause he is engaged in, and the inestimable rights he is contending for, hears you with patience, and acknowledges the truth of your observations, but adds that it is of no more consequence to him than to others." Such was the opinion and experience of one of the finest of soldiers after several years of trial of militia and volunteer systems; and our own experience toward the end of the Boer War was similar, when it became difficult to raise volunteers even with pay at 5s. a day. It is training under the law of the land which makes soldiers.

My desire is to inculcate the lesson that the defence of our coasts is the defence of our own homes, and that it takes but a little sacrifice of time to learn to manipulate a gun. Probably two months a year would suffice, and it would be no great hardship for every youth along our coasts to be made to serve two months every year for three years. In time of war, all those not required for the guns would then be available as reserves and be armed with rifles.

The number of men actually required to man the guns of my estimate may thus be roughly calculated as under:—

Heavy Guns	... ...	2 × 36 × 50 = 3,600
4·7″ ,,	... ...	4 × 36 × 30 = 4,320
15-pr. ,,	... ...	4 × 72 × 30 = 8,640
Machine ,,	... ...	6 × 144 × 10 = 8,640
	Total	25,200

Assuming that this number of men were paid 3s. a day, to cover everything, for a training of 60 days a year, the cost would be £226,800 per annum; and if one fresh contingent joined each year and each contingent served for three years, the total annual cost would be £680,400, less waste. This sum could be reduced to nearly half by requiring only 30 days training in the second and third year, except for experts such as gunlayers, besides occasional surprise mobilisations. After three years with the Colours each contingent would be liable,

* "They are ringing the bells now, they will be wringing their hands soon," said Walpole when the City bells pealed on the declaration of war with Spain.

"The press teamed with bombastic articles * * * the need for discipline and training * * was scornfully repudiated. Ignorance of war and contempt for the lessons of history were to cost the nation dear." —Henderson's *Stonewall Jackson.*

during a further term of six years, to be called up as reserves in case of war.

In this estimate the gun detachments have purposely been taken at excessive strength, not only to allow for casualties, but to be sure of not under-estimating. A certain number of men of the garrison would be required as escort, for defence of fixed emplacements with rifles against small boat attacks at night, and as signallers, sentries, and so forth, over and above cook-mates and fatigues. Similarly I have shown the cost of three contingents for two reasons :—(1) assuming the men to be Volunteers, only a proportion would report themselves for duty, or remain out for any length of time; they would have to come out in reliefs. (2) if, on the other hand, they were raised by compulsion, all men would have to be trained; although in time of war only a certain number need be called up, yet in all probability three contingents would be desirable, allowing two of these to act as riflemen or infantry in the intervals between the fixed batteries and as guards, etc.

The estimate is not intended to be complete, but only to enable a rough idea of cost to be arrived at and to show how very cheap such a system would be; each reader must draw his own deductions and complete the estimate. But the figures suffice to show at how small a cost our coasts might be made practically secure against raids. It seems certain that, otherwise, in case of national alarm, agitation for Coast Defence must again occur with its inevitable tendency to hamper the freedom of action of our Navy.

The carrying trade is gravitating every day more to our southern shores, and foreign ships are becoming daily better acquainted with them. Thus the interests to be protected grow greater, and the dangers to which we are exposed grow in proportion. Even granting commerce tends towards peace, the danger of war, in case we slumber, is increased. Impenetrable China is awakening from her dream! Shall we in turn doze, fancying ourselves safe behind our wall of iron ships?

THE PROTECTION OF BUILDINGS FROM LIGHTNING.*

By Alfred Hands, F.R. Met. S.

The privilege that has been accorded me of addressing you on the protection of buildings from lightning is particularly appreciated because I believe it is the first time an independent expert has had the honour of addressing your Corps on the subject. In 1861 Sir Wm. Snow Harris arranged to deliver a course of lectures at Chatham; but a painful malady, that resulted in almost total blindness, prevented his delivering them. This was a loss, not alone to the Royal Engineers, but to the whole world, for Snow Harris was a master of the subject. He owed his grasp of it to the fact that he was not only an experimenter but had investigated a great number of cases in which damage had been caused by lightning, and he drew his deductions largely from the experiments that nature had carried out. It is only because I, too, have devoted considerable time to inspecting cases of lightning damage, and especially those in which lightning conductors have failed, that I have ventured to bring the subject before you. In the course of this investigation I have come across many cases that, I think, throw considerable light on this intricate subject; and I shall try and bring some of these before you, to explain the conclusions at which I have arrived and the methods I have found advisable to adopt in protecting buildings.

Frequency of Damage by Lightning.

It is scarcely necessary to insist on the fact that a very great amount of damage is caused by lightning in this country every year; but it may be of interest to call your attention to a chart of England and Wales on which I have for some years been marking the positions and nature of objects damaged by lightning by differently coloured spots. I have collected particulars of such occurrences for the past 17 years, and, when all are located, I hope it will give some indication as to the relative frequency of lightning strokes on different soils. At present I have only completed a little over 9 years; but even at this stage two facts are shown that are contrary to popular opinion.

* Lecture delivered at the School of Military Engineering, Chatham, on December 6, 1906. The "Experiments" were all explained by realistic models.

Firstly, damage occurs more frequently in towns and densely populated districts than in the open country; with a few exceptions, wherever there is a collection of spots a town is situated, and in this way nearly all towns of importance, and especially the large manufacturing centres, are indicated. Secondly, the cases also occur more often along valleys and on comparatively low lands than on the heights, doubtless because storms are liable to follow the courses of valleys. I may mention that there are on this chart 5,767 spots;—representing 2,485 buildings (of which 148 are churches); 929 trees; 196 ricks and stacks; 172 persons killed and 728 injured; 1,004 cases in which animals were killed, varying from single ones to as many as 45 in a flock; and 253 objects not covered by any of the other classes.

THE LIGHTNING RESEARCH COMMITTEE'S REPORT.

It is impossible to approach the subject of protection from lightning without referring to the present aspect of the matter in the popular mind and the causes that have led to it. There is at the present moment a great deal of scepticism as to the utility of lightning conductors; and this has been caused, directly and indirectly, by the recent so-called Lightning Research Committee and its Report published last year. Time will not permit me to point out all the peculiarities of this Report; however, I may say that it is not only so contradictory that one cannot say definitely what is or is not recommended, but it contains grave mis-statements that would lead the public to suppose that science had been seriously at fault and that, what I may call, orthodox methods of protection are useless.

It states that, out of 115 reports of disasters which occurred during the three years the Committee was collecting particulars, 40 related to buildings fitted with lightning conductors. These figures were apparently communicated to the press before the Report was published; and they naturally led to comments that, if one out of every three buildings damaged by lightning had conductors, then conductors must not only be useless but might even be a source of added danger. I have since challenged these figures and obtained a public admission that they are incorrect. As a matter of fact, during those three years, nearly 1,200 buildings were damaged by lightning in this country, and of these only 24 had conductors.

The recommendations of this Committee are of no more value than its statistics. They are avowedly founded on reports by observers, most of whom knew nothing of the subject and were incompetent to form a correct estimate of what they saw; and the reports were in many cases remarkable for their inaccuracy. It is curious how reports often distort facts into extraordinary occurrences that one would think a little scientific knowledge would show to be contrary to the laws of nature.

In explaining some of the cases, I will give the published descriptions as a contrast and to show how little such reports can be relied upon to govern our views of the matter. I may explain that in the diagrams I have tried to illustrate the structures in the way they appear to me; that is, I have given a sort of Röntgen ray view, with the idea of relative resistance conveyed by shade. Thus, the air, resisting most, is shown black; buildings, resisting less well than air, are shown grey; and metals, resisting very little, are shown white. The ground is shown grey near the surface but white below to indicate the conducting stratum that may be regarded as good "earth."

THE SCIENCE OF LIGHTNING PROTECTION.

The science of protection from lightning is not an easy one, but why is it difficult? We know that, in accordance with electrical law, a discharge will take the path of low resistance in preference to that with a high one. If we took a piece of stone and placed a line of metal along it from end to end, except for a break in the centre, and then subjected it to a discharge from an electrical machine; or, if we had a real obelisk composed only of the same material, and fitted it with metal in the same way, and it was struck by lightning—the spark would pass along the metal. If damage occurred it would only be at the gap; the discharge would not go through the masonry in preference to the metal. The experiment might be repeated any number of times, either with the model in the laboratory or with a real obelisk and nature, and the result would be the same.

(1). A Sussex church that was struck in 1891 illustrates the obelisk I have been explaining. Someone was looking at the clock at the time, and declared he saw the flash strike it obliquely in a certain direction. We will let our spark strike the vane and watch the effect. Examples of Damage by Lightning.

(*Experiment.*—Spark strikes vane, and another spark appears between clock and nave roof).

The explanation is that the bolt rod of the vane, instead of extending down a few feet only as usual, was carried down the whole length of the spire, about 40 or 50 ft., and ended just above the works of the clock; a piece of copper wire, passing from near the lower end of the bolt rod to the clock works, formed a connecting link between the two. The course of the discharge, therefore, was from the vane, down the bolt rod, and through the copper wire (which was fused) to the clock works and face, this part of the course being invisible, not only because it was within an enclosed space, but because it formed a conducting system. The discharge then passed, as a luminous one through the masonry of the tower, shattering it, and finally to earth by the lead flashing and rain pipe. What the observer saw was the bright light here and he imagined the rest.

I may add that my description is not entirely hypothesis. In all the cases I am showing there were the usual clues that one picks up as one goes along—clues which might appear insignificant individually, but which, taken in conjunction with one another, form convincing chains of evidence.

Reverting to the obelisk, if we completed the line of metal so as to form a continuous conductor, the obelisk would be protected. Electrically bad joints and a bad earth connection would not force the discharge to go through the masonry. Bad joints would only cause injury to the conductor; and a bad "earth" would probably result in a barrow load or so of soil being blown up. The concussion due to the explosive force that blew up the ground might possibly crack the masonry slightly on the surface, but this would be the worst that would happen.

Rival Conductors as Alternative Paths.

But if the obelisk, in place of being solid masonry, was built hollow, with stone steps in the interior, and with a gas pipe carried up inside to afford light at intervals, the problem would be an entirely different one. There would be a rival conductor in the interior—an alternative path of metal—with a perfect earth connection because the ramifications of the gas main underground would afford only a nominal resistance to earth. Therefore, if the intended conductor had a high resistance, the bulk of the discharge would spark through the wall and pass to earth by the gas system. The earth resistance of a gas main is a mere fraction of an ohm, and it is practically impossible to get an appreciably lower one for the conductor; so, even if we gave the latter what is called a "good earth," there would still be the rival in the interior and the danger of division of the discharge between the two paths of metal, for a thickness of a foot or two of masonry is poor insulation to withstand the voltage of a lightning flash.

For efficiency it would not only be necessary to have a conductor with a minimum resistance, but it should be fixed on the opposite side of the structure to the gas pipe, so that there would be a sufficiently thick buffer of insulating material between them and the discharge would not be able to spark through. I consider the safe distance for masonry or brickwork to be a little over 4 ft.; less than this is risky, because the question of sparking through the wall would depend on the relative thickness of the masonry and the power of the flash.

(2). I will reproduce a case of alternative path that occurred in North London (*Fig.* 1). The case was described as follows in a list of reports issued by the Lightning Research Committee and exhibited at Earl's Court Exhibition in 1903:—"February 26, 1901. London: German Lutheran Church, Ritson Road, Dalston. Flash passed through rose window at north end, leaving stone tracery intact but destroying the organ immediately behind it and setting fire to the timbers of organ loft."

The evidence that appeared to warrant this peculiar report was the fact that the spire was uninjured; on the other hand, the north window was destroyed, indicating apparently that lightning had passed through it, and a fire was caused at this end of the nave that did, I believe, about £2,000 damage. According to this, lightning ignored the tall spire, about 170 ft. in height, that had a lightning conductor upon it; ignored even the north gable, close to which it was supposed to have passed, that had lead flashing down both sides, which, in conjunction with the rain gutters and down pipes, formed lines of conducting material almost to the ground—it ignored these, because it preferred a path of infinitely greater resistance through the air to curl in through a window, about 20 or 30 ft. from the ground, being attracted, I suppose by some organ pipes! Yet it was sufficiently satisfactory for the Research Committee to accept and print in its records.

We will reproduce the case, letting the discharge do the orthodox thing and strike the vane on the spire.

(*Experiment.*—Spark strikes vane and fire occurs at meter and spreads up staircase to organ loft).

The case is set out in diagrammatic form in the illustration, and it will perhaps make my explanation more clear. Attached to the bolt rod of the vane was a lightning conductor carried down inside the spire and out through one of the windows, where it descended the tower and ended in a rain down pipe in this corner, so that there was practically no earth connection. The down pipe was in contact with the lead flashing that passed up round the back of the tower to the other side, where there was another down pipe. Near this was a gas lamp, set to light the passage; the gas pipe passed through the wall to the interior and along to the meter at the north end. There were, therefore, two lines of metal; one, the lightning conductor continued by the rain pipe with a bad "earth"; the other, the conductor continued by the lead flashing, rain pipe, and gas pipe, to the perfect "earth" afforded by the gas main; and lightning took the path of least resistance.

That a fire was caused at the meter, owing possibly to a bad joint, but more probably to crossed inlet and outlet pipes, was a natural consequence; and it was also a natural consequence, I think, that the fire, having started in a cupboard under some wooden stairs, should have spread up the staircase to the organ loft, burnt the organ, and melted the leaded lights of the window.

Effect of Abrupt Bends in Conductors.

We have heard a great deal lately about abrupt bends in a conductor causing a discharge to side-flash to neighbouring metals. This opinion has arisen in a rather curious way. Sir Oliver Lodge has written a work on lightning conductors that is a valuable contribution to the subject from a theoretical point of view, though his practical deductions are, I consider, unsound and not warranted. In one part of this book, he says that lightning has no time to go round; it will jump across in preference, which, in a certain sense might appear correct. In another place he says that self-induction causes side-flash, which statement, taken by itself, appears true, since we know that by reducing self-induction we can decrease the length of the side-flash. Certain electricians appear to have married one statement to the other; and the issue of this morganatic union is the statement that abrupt bends increase self-induction and so cause side-flash. So much has this been asserted, that even many electricians are convinced it is true although it is contrary to electrical law. A straight wire has a certain amount of self-induction; twist it into a spiral and this is increased enormously; but zigzag it backwards and forwards, giving it in fact a number of extremely abrupt bends, and self-deduction and consequent side-flash are reduced to a minimum.

(3). I want to call your attention to the course followed in this case, the discharge going by nine abrupt bends to get to a good earth in preference to a straight course to a bad one. While I have the model here I will show you a variation of the last experiment. I cut away the lead flashing that connects one side of the tower with the other, so that this alternative path is no longer open. We let the spark strike the vane as before.

(*Experiment.*—Spark strikes vane, and fire is again caused at the meter, with the same result, because there is now another alternative path open).

When making this model I placed a line of lead foil over the south gable to represent lead flashing, although, if I remember rightly, there was none in the original. Its being here did not affect the first experiment because I left a break at the back that was afterwards made up with a piece of wire. It now enables me to show you what a roundabout course a discharge will travel, and how necessary it is to guard against alternative paths no matter how circuitous. The course is now down the conductor; along the rain gutter southward; up the roof and down to the east side; along the rain gutter northward; up again over the roof to the west side; along the rain gutter southward; down the rain pipe; back to the gas lamp; and on by the combination as before.

It might be asked—"How is it possible to protect this building, since, however perfect the lightning conductor in that corner, there is always open the alternative path to an earth connection at least as perfect as that of the conductor?" If we followed the Lightning Research Committee's recommendation and put two, or even a dozen, conductors on the spire, the same thing would still happen. Protection is a much more simple matter than this; run the conductor down the south-west corner, and it would then be sufficiently far removed from these dangerous complications.

The obelisk I have been explaining is the simplest possible case.

If all buildings were as simple as this, protection from lightning would be so ridiculously easy that a Council schoolboy could, by means of a few set rules, learn to protect them efficiently. The problem one is sometimes confronted with is more like this:—Metal cowls on chimneys; lead-covered ridges and flashings; metal girders, stoves, and casements; rain water gutters and pipes, gas and water service pipes, etc.,—altogether affording a problem that would require very careful studying.

Examples of Lightning Conductor Failure.

Before going further into the matter I will show you a few cases of so-called lightning conductor failure in diagrammatic form.* I regret that time did not allow of my making models so as to reproduce these experimentally also.

(4). On the tower of Stradbroke Church, Suffolk, struck about 5 years ago, a lightning conductor was fixed to the corner turret, but not connected to the vane; therefore, if the turret had been struck, the masonry between the vane rod and the conductor would have suffered. The point struck, however, was the flagstaff at the opposite corner, that had no conductor. The course of the discharge, after shattering the flagstaff, was along the lead roofing, up to the metal hinges of the turret door, and then through the masonry to the conductor, by which it passed to earth without further damage, although the resistance to earth was about 900 ohms; there was no possible alternative path in this case.

The system I recommended comprised a main conductor from the flagstaff, with branches from the vane and the two other pinnacles, the whole being connected to the lead roof.

(5). *Fig. 2* shows Needwood Church, Staffordshire, struck about 14 years ago. The system comprised a main conductor from one pinnacle to an earth with a copper plate, 3 ft. × 3 ft. × $\frac{1}{8}$ in., bedded in clay soil, the resistance being about 12 ohms, and branches from the other three pinnacles. A very bad bend was formed by the conductor being carried down to the lead roof and then up again over the parapet wall. The discharge did not spark through the parapet, but the conductor was ripped loose there. I have on several occasions noticed what I take to be a tendency for a conductor to straighten itself when struck by lightning; and, if the fastenings are not very secure, a bad bend like this leads to the conductor being torn loose.

On the ground floor, inside the nave, was matting the ends of which were bound with lead about equal to a 1-inch pipe flattened out. There were three lengths of lead binding, the first one being just behind the conductor, and the second just above a large metal stove that rested on a damp floor in a vault. This combination formed an alternative path; and part of the discharge sparked from

* Owing to financial reasons only a few of the diagrams have been reproduced.—EDR.

the conductor through the wall to the first lead binding, on to the next length, and through the floor to the stove. The discharge was undoubtedly exceptionally severe in this case.

The course of the conductor was altered so as to do away with the up-and-down bend, and the lead binding was ordered to be removed.

(6). In Kea Church, Cornwall, struck about six years ago, the spire was entirely copper covered, but a conductor was carried over it from the vane to the ground. I was told there was an earth plate, but did not test it, and do not know the resistance; as the church is on a hillside the resistance would probably be rather high. It was reported that lightning had struck the roof of the nave close to the spire, because this was the only place damaged, but I found that the vane had been struck. The discharge had divided between the conductor and a rain down pipe in the corner, both being connected at the top by the metal roof, and both having practically the same earth connection because a piece of copper wire, put up to support some creepers, was stretched across from one to the other a few feet above the ground. The portion of the discharge that passed down the rain pipe divided again by sparking through the parapet wall to the lead flashing (down the roof of the nave), which, with the rain gutter and down pipe by the porch, formed another line of metal to the ground.

I believe the authorities afterwards had the rain pipes earthed with the idea of letting the electricity escape, which would only make matters worse; what was wanted was a connection of metal across the top of the parapet wall from the rain pipe to the lead flashing.

(7). *Fig.* 3 shows a very common case,—a short elevation rod fixed on a chimney, and near it a much higher mass of metal in the form of a cowl. The discharge passed through the cowl, and shattered the corner of the stack in passing to the conductor. Here the elevation rod should have been fixed on the cowl, or else a connection of metal should have been made from the cowl to the conductor.

Surging Effect of Lightning Discharges.

These cases are all comparatively simple ones. I propose showing next some results due to the surging effect of a discharge; and, as this is often overlooked and is possibly not very generally understood, I will explain it first in case anyone present has not considered the matter. Electricity—or, perhaps, I should say, the movement in the ether that causes electrical effects—has properties that correspond to inertia and momentum in matter, and in scientific terms they are called electro-magnetic-inertia and electro-kinetic-momentum. We have to remember that when a conducting system receives a discharge, it is momentarily charged because of inertia having to be overcome, and the consequent sudden rise and fall of potential does not leave outlying parts of the system at a normal level. There is an alternate rise and fall like the water in a bath that has been tipped up suddenly at one end. Although the effect is all over in a fraction of a second, damage might occur which, although slight in itself, might have serious results; so precautions should be taken to guard against it.

Although water is not a good analogy, it is the best I can think of to bring the action to mind. Imagine a system of canals. Suppose a main canal, open to the sea, and equivalent to a conductor with a good earth connection. To right and left suppose two branch canals, equal to branch lines of metal from the conductor, the former having only a very weak wall dividing it from a pool of water, while all the other banks are sufficiently high and strong to resist pressure due to the rise and fall of the water level. The pool represents a piece of metal near the far end of the branch conductor and not connected to it. If the level of the water in the main canal were suddenly raised enormously, there would be a rush along the canal due to the passage of the extra head of water to the sea, but the water in the branch canals would not remain at normal sea level; there would be a surging effect along them. In the left hand canal there would be no effect beyond the rise and fall of water; but with the right hand one, the dividing wall, being very weak, might be broken down. The strength of the wall represents the insulating strength—or, in other words, the distance—between the branch conductor and the adjacent metal, and would determine whether a breakdown, or spark, occurred between the two.

(8). Some 10 or 12 years ago lightning was said to have struck down inside a brick chimney on the ridge of a small corrugated iron building situated close to Happisburgh Lighthouse. It did not damage the chimney; it did not even avail itself of the large amount of conducting material afforded by the metal sheeting to get to earth; it passed down the centre of the flue and then, in some mysterious way, got to a gas pipe and caused a fire by lighting the gas! In order that you may be able to see into the interior, I have covered the model with wire gauze in place of metal sheeting, but the effect, from an electrical point of view, is the same. We will let a spark strike the lighthouse and see what happens.

(*Experiment.*—Spark strikes lighthouse and fire breaks out in small building).

In explanation I may say that the lightning conductor system in use for English lighthouses is practically that recommended by Faraday in 1843: a stout bar of half-round copper is connected to the metal-work of the lantern, and carried down inside the lighthouse, being connected to all the metals in the interior. At the bottom it passes out to an ordinary copper-plate earth connection.

In this case a pipe from the gas-making house passed underground to the lighthouse and up to the top to provide gas for the lantern, and this pipe was, of course, in connection with the lightning conductor. Another pipe, in connection with the first one, passed underground to provide light for a small building, which was in use at the time as men's quarters. There was, therefore, a line of metal, connected to the lightning conductor at the top of the lighthouse and carried along underground into the small building, but not connected to the iron framework or corrugated iron covering of the latter; there was a small gap between the pipe and the framework of the building, and here, owing to the surging effect I have described, a spark would occur, lighting the gas, as it has done in the experiment.

The cure in this case is a very simple one; connect the outer sheathing of the building to the gas pipe where it enters the structure, or (else) the gas pipe to the iron framework where it passes near to it, and no spark will occur.

Distant Effects of Lightning.

We next come to effects that are by no means uncommon but have hitherto been misrepresented owing to their not having been understood; cases in which objects are struck by lightning and effects occur at some distance away. For instance, a church spire might be struck, with or without a conductor upon it, and persons in a neighbouring house, who happened to have metals in their hands at the time, might receive slight shocks that would perhaps appear severe because they were unexpected. A man walking with a gun on his shoulder near a tree when it was struck would get a shock, and say he had been struck too. Workmen handling metal tools are especially liable to these effects when near lightning-struck spots. The Vicar of St. Agnes, Scorrier, Cornwall, sent me this year an account of a storm in which there was only one flash; this struck and damaged his church, and men in a mine about 500 yards away and at a depth of 260 to 320 yards below the surface received shocks.

I regard these effects as due to a surging or wave effect, somewhat similar to what I have been describing but with the earth as the conductor between in place of a line of metal. It is often thought that when a lightning flash reaches the earth—to put it in popular language—the effect is all over; but we must bear in mind that generally, before a discharge occurs, the potential of a locality is raised—or lowered as the case may be—enormously, and this altered potential does not necessarily return to the normal again without effect. Taking a water analogy again, I would liken it to a waterspout forming on the surface of a lake and then suddenly collapsing. The effect would not be over the moment the column of water struck the surface; there would be a surging or wave effect that might loosen the banks at some distance away where they happened to be weak. So with a lightning discharge, we may imagine the sudden rise and fall of potential as setting electrical waves flying through the earth; where metals were so placed as to give rise to a difference of potential of sufficient magnitude, there the effects would be felt as shocks by persons in the position of links between those metals and the earth, or the effects would appear as sparks where two metals were so placed as to be just in the right way to catch these waves. This is how the matter presents itself to my mind; and I have found it explain many incidents that had appeared mysterious and that could have been foreseen under this aspect of the matter and, it appears to me, under this aspect only.

The greatest distance to which I have so far been able to trace effects of this kind has been about half a mile; but possibly, if the discharge were exceptionally severe or the conditions unusually favourable, effects might be traced even further. These cases are difficult to reproduce because of the difficulty of reproducing the exact conditions in a lecture theatre. In the experimental reproduction I must be content to have my models only a few yards apart. I have been tempted to select this case principally because, from seeing the marks where a slight fire had occurred, I was able to deduce the circumstances, and also in this case there was a witness.

(9). I was at Heathfield Station in Sussex one day when I noticed marks of burning and a combination of metals that led me to think I had accidentally come across an interesting case, and, having time to spare, I examined the buildings carefully. The railway line here is in a cutting, over which there is a road bridge. Above the platform on one side of the station is the booking office, abutting on to and level with the road. From one end of the booking office a footbridge, roofed with corrugated iron, leads across the line to give access to the other platform. From a gas main along the road a pipe runs into the footbridge just outside the booking office, and rises up to a gas jet not far below the roof of the footbridge. Some telegraph wires terminate in shackles on the wall of the booking office above the footbridge; and from these shackles insulated wires were carried into the booking office, passing on their way down the roof of the footbridge and within about an inch of the gas pipe, thus forming a connecting link between the iron pipe and the iron roof. The rubber covering of these wires had been ignited just by the gas pipe, and the small fire occasioned had scorched some adjoining woodwork.

I came to the conclusion that lightning had not struck the station, although enquiries elicited the fact that the fire had occurred during a thunderstorm. A signalman walking along the line towards the station said he did not see lightning strike there, although he was looking that way and saw the fire occur. I indicated two directions, in one of which I thought it probable that some object within about half a mile had been struck at the time of the occurrence; and I was told that a house, just about half a mile away and in one of the two directions I had indicated, had been struck and, it was believed, at precisely the same time.

What no doubt happened was this. When the lightning struck the house the discharge passed away in all directions; the portion going in the direction of the station was in due course more or less concentrated along the gas pipe leading to the station; the potential of this pipe, terminating near the roof of the footbridge, was raised, but that of the roof, which was insulated, remained normal; thus a difference of potential was created, which was sufficient to cause a spark between the two, across the gap between the pipe and the insulated wires, and this spark ignited the covering of the wires and caused the fire.

(*Experiment.*—Spark strikes house and fire occurs at railway station).

In this type of case there is no metallic connection between the buildings; the earth carries the wave or impulse. Whatever the object the discharge strikes, and whatever resistance it meets with, it must go to good earth, and the earth forms the conductor that carries the wave or impulse to the second object. All that is required at, what I may call, the receiver end is the suitable arrangement of metal to produce the difference of potential that will cause a spark. In the instance under reference it was the gas pipe passing along the road from the direction of the struck building (but not actually from that building) and the long length of corrugated iron roofing insulated from the ground on a wooden frame. The spark could have been prevented by making a proper connection between the iron roof and the gas pipe, or by placing the telegraph wires so that they should not form a partial connection.

It is not only one "earthed" and one insulated metal that would cause such a spark. Two "earthed" metals, such as a gas pipe and a water pipe entering a building from opposite directions and on opposite sides, and crossing or closely approaching one another inside the building, would be liable to cause a spark; and when they do enter from opposite sides in this manner (rather unusual) the case wants looking into very carefully.

Complications liable to cause Failure.

The cases I have described are ones that have actually occurred. It may be said, it is easy enough to see these things after the events; what we require to do is to see them before they occur. So I will show you a few complications I have had to deal with that had not been struck by lightning.

(10). *Fig.* 4 shows one end of the Bristol Corporation Granary. This had a conductor system in perfect order. But a telephone wire had been run to a shackle close to one of the conductors, and thence on to the instrument in a small wood-lined building used as offices, where it passed across a soft metal gas pipe. Had the granary been struck, a part of the discharge would have been led by this alternative path to the gas pipe, fusing a hole in it and causing a fire; so I ordered the telephone wire to be moved well away from the conductor.

(11). *Fig.* 5 shows part of a mansion in Sussex. A conductor had been fixed from the vane on the tower and well earthed, but afterwards metal rods were run from the vane to work an indicating dial in the hall. On the basement floor, below the dial, was an iron door, and running near this, almost in contact with the door, was a water supply pipe. The distance from the dial to the door would, under ordinary circumstances, have been too far for part of the discharge to break through; but, had anyone been standing looking at the dial at the moment the vane was struck, his body would have so far weakened the gap that a very severe, or possibly fatal, shock would have resulted. So a connection was run from the dial to the iron door, water pipe, and conductor earth.

(12). *Fig.* 6 is one of the east towers of Westminster Cathedral. The ledges were covered with lead, brick buttresses separating one piece of lead from another. Sparking would have been liable to occur from the one sheet of lead in contact with the conductor to the others; so connections were put in from one piece of lead to the next all round the tower. Inside the tower was an iron staircase, the top enclosed by a sort of wood canopy roofed with lead. Had anyone been standing at the top of the stairs at the moment the conductor was struck, his head would have been perilously near the lead; he would have formed a connecting link between the two masses of metal, and would have been liable to a rather unpleasant shock due to an induced effect. So I had a connection made from the lead to the handrail of the staircase and on to the conductor.

(13). *Fig.* 7 is the Lady Chapel at the east end of Gloucester Cathedral. On one of my periodical visits of inspection, I found that a radiator stove had been put in, with a metal flue pipe that was carried up and in connection with the lead roof, which was, of course, connected to the conductor. The stove rested on a gas pipe; so there was an alternative path from the conductor system, consisting of the lead roof, the flue pipe, the stove, and the gas pipe that passed along the entire length of the cathedral. I recommended that the gas pipe should be diverted to the other side of the chapel.

(14). *Fig.* 8 shows rather a complicated case,—a large hall lighted by gas pendants from a supply pipe passing along under the ridge. Usually such a building would be protected by a point at each gable, with a copper tape carried along the ridge from one gable to the other and down to earth at some place between. But here a dangerous alternative path exists right under the ridge, and the conductor would require to be kept away from it. Therefore an independent conductor at each end, both perfectly earthed, would be necessary.

Chimney Shafts.

Chimney shafts often present difficulties in regard to protection. When hoop iron is built in for bond, there is a weak spot wherever the iron comes near the conductor; therefore, when the hoop irons are being laid, tail pieces should be brought out from them to be connected to the conductor when it is fixed. In such cases the danger of side flash would be near the top and bottom rather than in the centre.

Sometimes a metal steam pipe is carried up inside a shaft. Here it is necessary to connect to the conductor at the top, and either connect at the bottom also or otherwise earth the pipe. Besides this it is necessary to trace the pipe to its source; and make connections to any metals near it at places where damage would occur through sparking, and also possibly between one metal and another.

The various effects and complications I have described may justify me in saying that it is impossible to protect buildings from lightning by means of set rules. Each case must be studied separately, and such a system of protection applied as the complications found in the case may show to be necessary.

METHODS OF PROTECTION.

Now, how are buildings to be protected? We may say broadly that there are three methods that might be adopted.

Firstly there is the cage system. If you have a metal box you can get no electrical effects in the interior; and if a building could be metal plated, so as to be like a biscuit tin with the lid on, it would be quite lightning proof, but no metal must be allowed to pass into the interior without being first connected to the metal sheathing. The advantage of this method would be that no knowledge of the subject and no study of the problem involved by the complications of metal in the structure would be necessary. It is *par excellence* the novice's method. It is not even necessary to cover the building with continuous sheets of metal; if conductors were arranged so as to form a close meshed network all over it—so as to make it resemble a birdcage—it would still form a screen against effects in the interior.

But a mere skeleton of a cage, the system that the Lightning Research Committee advocates in one part of its Report and condemns as inefficient in another, does not afford this screening effect even to a partial extent; and the worst damage that has occurred to buildings through faultily applied conductors could still occur to one fitted with what I call the bastard cage system, if the conditions were conducive to those effects. In fact I regard a partial cage system as liable to be extra hazardous, because, while one can arrange to keep a limited number of conductors on a building clear of metals that might cause complications, it might be found impossible to arrange them in all directions in this way. If an explosives magazine was fitted with such a system, I think I could add a contrivance that would cause it to explode if lightning struck anywhere within half a mile. We have a good example of the failure of the partial cage system in the Hotel de Ville, Brussels, one of the very few buildings that have been fitted with this system; it was struck and set on fire about 16 years ago.

For the majority of buildings the complete cage system is quite impracticable. Apart from the prohibitive cost, I have yet to find the architect, or even the owner, who would consent to have his building turned into a glorified aviary. Then such a luxury as a telephone service would have to be dispensed with, since to connect the wires to the cage would be impossible, and, if introduced without being connected, they might nullify the screening effect of the cage. This system may, however, be applied with advantage in protecting explosives magazines; indeed it is often a most difficult matter to protect them in any other way, because, I presume, the metals in the interior are constantly liable to change and re-arrangement. If one could be certain that the problem one studied in the first instance would be the one always in existence and not a different one set from time to time, a much more simple method could be devised.

The second method is to connect every particle of metal in and about the structure to one another and to the conductor system. Then no sparking or side-flash would occur, because there would be no gaps between metals where, owing to difference of potential, sparks could occur. This method is the one attempted by Trinity House for lighthouses, but for ordinary buildings it is impracticable also.

The third method, which I regard as the practical one, gives, I think, the maximum of efficiency with the minimum of cost; but it necessitates a profound study of the subject and very careful consideration of the buildings to be protected. First one must determine what are the parts of the building liable to be struck, and run continuous lines of metal from these to good earth connections, either as main conductors, or as mains and branches, as may be most effective; then one must consider the effect that would occur if either of those conductors was struck by lightning, and make connections across any sparking gaps, either between the conductor and other metals or between those other metals themselves, if the sparks were calculated to do harm.

There are some metals about a building that should not be brought into connection with the conductor system, and these should be carefully avoided by giving the conductor a course that is beyond sparking distance. The question as to what shall, and what shall not, be connected is the most difficult one of all to decide, and no fixed rule can be laid down; it must be decided by the problem found to be involved.

Knowledge necessary for Success in Protection.

In considering the subject of protection from lightning, I think that too much importance has hitherto been attached to the form and composition of the conductor, and too little to the fact that its efficiency depends very little on what it is but almost entirely on the way in which it is applied. The subject is somewhat analogous to the work of a medical practitioner, who has to consider the symptoms and characteristics of his patient, and prescribes the remedies that his diagnosis of the case suggests; the result will depend on the ability of the doctor and the correctness of his views. Although the case that the lightning protection expert has to study is not one of existing disease, it is one where the possibility of bad results is before him; he has to consider the case on its merits, to determine all the effects that might occur, and to arrange his preventive devices in the way that he considers will be successful; he has, in fact, to diagnose the case, and the result will depend on the correctness of his diagnosis.

None of us can lay claim to infallibility, and anyone might make a mistake or fail to notice some factor that might have an important bearing on the matter; but the fact remains that the possession of knowledge, experience, and ability to discriminate as to the importance of details should enable a man to protect a building effectively, while absence of these would probably result in failure. At all events, it is in this direction, I think, that we should strive to improve our methods, and not in trying to devise theoretically perfect, but practically impossible, mechanical ones, the only advantage of which would be to save the trouble of having to study the subject.

Relative Values of Copper and Iron as Conductors.

I have devoted the time at my disposal to the points I regard as of paramount importance, but you would probably consider my remarks incomplete if I did not refer to the relative value of copper and iron for conductors.

So far as regards conductivity and dissipation of energy, the matter is, I consider, of such trifling importance that it sinks into insignificance in comparison with considerations of durability. A conductor is expected to last a long time, and iron, even if galvanized, is very perishable; so we are left with copper as the alternative of these two metals. As regards the advantage of iron dissipating the energy of a discharge, this has been demonstrated experimentally and such work is often of very great value; but there are cases where it is necessary to take proportion into account. I might show you that by hanging a sheet of tissue paper loosely in front of a popgun I could impede the velocity of the cork; but, if I suggested the advisability of hanging sheets of tissue paper before men exposed to rifle fire, you would probably think my friends ought to put me under restraint. The experiments that show the superiority of iron are, I think, almost on a par with this. They show that a thin iron wire about a hundred feet long has a decided advantage in dissipating the energy of a six-inch spark; but if you were to repeat the experiments with a conducting wire about one-sixteenth of an inch long and a six-inch spark—which would be about proportional to a lightning conductor a hundred feet long being struck by a lightning flash half a mile in length—you would see what I mean by saying that, in my opinion, the matter is of trifling importance.

CONCLUSION.

There are, I presume, many present who are taking up the subject of protection from lightning as a serious study, and to those I would say—Do not think it is a dull one, merely because I may have failed to put it attractively. You will find that the deeper you go into it the greater the interest grows. New problems and fresh complications are constantly being met with and the field is very far from being exhausted; there is room for further investigation. And do not be discouraged because you meet with or hear of cases that appear, at first sight, inexplicable; there can be no such things as vagaries or freaks of lightning. I have devoted considerable time to investigating so-called vagaries and never yet found one that, on being thoroughly probed into, did not prove to be consistent and in accordance with our knowledge of the subject. There are laws governing all natural phenomena, and lightning, like every other force in nature, must be amenable to law. We do not yet know all those laws; but they are gradually being revealed, and, where we do not understand them, we should try and clear up the mystery and not dismiss the matter by saying that in one respect nature is erratic.

MEMOIR.

Colonel Charles John Smith, late R.E.

On the 4th January, 1907, there died at his residence at Bideford, Devon, Colonel Charles John Smith, Royal (Madras) Engineers, retired, in his 71st year.

Born on 11th July, 1836, his early life was spent at Bury St. Edmunds, where his father was for many years a well-known medical practitioner. He was the eldest son of a large family, and was educated at King Edward VI. School in the town.

He joined the Honourable East India Company's Military Seminary at Addiscombe in February, 1854, received his commission in the Company's Engineers on the 7th December, 1855, joined the Royal Engineers at Chatham in February, 1856, and, having been posted to the Madras Engineers, arrived in Madras on the 26th December, 1857.

On arrival in India he was posted to the Public Works Department, and was employed on important irrigation works in the Nellore, Tanjore, and Kistna Districts, and on special investigation, until 1870; and distinguished himself by his energy and activity and mastery of this branch of his profession.

In 1870 he was transferred to the Railway Branch of the P.W. Department as Deputy Consulting Engineer for Railways, and remained in this Branch until the end of his service in 1892, rising to be Head of the Department as Consulting Engineer and Secretary to Government Railway Branch, in 1883: higher preferment he declined, feeling that his experience of the Railway systems in Madras rendered him most useful to his own Government.

In the Railway Branch he was distinguished by his thorough knowledge of his work, his strong common sense, and his tact and ability; and he earned the respect and esteem of all those with whom he was officially brought in contact.

After leaving India he settled down at Bideford, where, although his health was not always good, he continued to do good work in connection with local public affairs.

In private life dear old C.J. (as he was called throughout the South of India) was universally beloved. He made friends wherever he went, and to very many he was a friend indeed through life. His was a deeply sympathetic nature and for those in trouble or sorrow he would spend and be spent to any extent. His life was a beautiful one because it was one of self-denial for the good of others; and his loss will be deeply mourned by his family and a very large circle of friends. He was unmarried.

H.

TRANSCRIPT.

RAILWAYS IN WAR AND MODERN VIEWS AS TO THEIR EMPLOYMENT.*

Means of communication have constituted a factor of decisive importance in the wars of every epoch of the history of the world. When railways first appeared upon the scene, the attention of military men was naturally directed to their strategical possibilities, the manner of their employment, and the extent to which they could be pressed into the service of war.

As is the case with every great idea, the most divergent views at first prevailed as to the value of the new invention and its applicability to military purposes. Some authorities prophesied a complete revolution in the art of war, while others considered that railways would at most be useful for the transport of war material and would not otherwise be of assistance in military operations.

Von Pönitz, the versatile military writer of that period, published in 1842 a book entitled *The Influence of Railways on Military Operations*, which is regarded as an authority on many points even at the present day. Thus, he lays down as essential that the Military Authorities should have an unrestricted right of way over all railways on the outbreak of war, and that there should be a special officer, entrusted with the control of railway transport, on the staff of the Quartermaster-General.

Von Pönitz did not, however, consider the possibility of the strategical concentration of the forces by rail; it was not till 1850, when this country was threatened with war with Prussia, that this was put into practice.

The railways in 1850 did an amount of work which was surprising in 1850.
view of the limited facilities then available,† but they did not materially expedite the strategical concentration; the troops might have reached their positions almost as quickly by road. In spite of the zeal of the railway officials, the want of a proper organization for war was severely felt; no preparations had been made beforehand, there were no transport regulations, and the whole transport scheme had to be improvised.

In spite of the experience gained in 1850 as to the shortcomings of the railways, it was ten years before our military knowledge of railways was sufficiently advanced to lay down the principles upon which the science of handling this, the mightiest of all means of locomotion, is based.

* Extracts from a lecture delivered by Lieut. Edward Zanantoni, Austrian General Staff (Railway Section), at the Austrian Railway Employés Institute, Vienna.

† In November, 1850, in 26 days, the railways conveyed 75,000 men, 8,000 horses, and 1,800 guns and wagons to the northern frontier of Austria. The maximum result, which was only once attained, was the despatch of eight trains of 120 axles in one day.

1859. It is not surprising, therefore, that the war of 1859 found both our Government and our railways unprepared. Once more it was found unavoidable to run trains without a fixed time-table, fitting them in as necessity dictated. The natural consequences of the neglect to organize the railways in peace-time followed; trains were delayed or blocked, and stations choked with a mass of supplies which could not be forwarded.

1862. Military Railway Regulations.

In 1862 the first "Regulations for the Transport of Troops by Rail" were issued. These were based on the experiences of 1850 and 1859; they were intended to constitute a complete scheme of railway transport, and to provide as far as possible for the safety of the traffic, even when the lines were worked to their full capacity.

Broadly speaking, the 1862 regulations were similar, in their principal provisions, to those in force at the present day. They laid down a transport scheme for the maximum carrying capacity of the railway; they fixed the speed of military trains at 12 to 15 miles an hour; they provided for the storage of military fittings for 10 per cent. of the covered goods wagons; and they laid down the formation of standard troop-trains for cavalry, artillery, and infantry.

As a single central authority to take charge of all military movements on a large scale by rail the Regulations created the "War Office Department of Railway Transport." To this department were subordinated various Railway Committees and Local Military Railway Committees; the latter are now replaced by the present Military Commanders of Railway Stations. Finally the Regulations created a Field Railways Department for the theatre of war.

Almost simultaneously with the 1862 regulations there appeared a book, which was then looked upon as a standard work, entitled *Railways from the Military Point of View*. The author, Capt. Panz, a staff officer in the Q.M.G.'s department, had the honour of being the first to embody the experience then gained into a logical and practical military system.

Capt. Panz laid down that all locomotives must be classified as to speed and power; that a reserve of 25 per cent. of locomotives and 15 per cent. of trucks must be allowed for repairs; that the maximum period given to railways to prepare for war was not to exceed ten days (to include re-arrangement of passenger traffic, unloading and collecting trucks, and equipping wagons for military transport); that for journeys lasting over 8 hours provision must be made for feeding the troops, and for journeys of 48 hours or more for quartering them; and finally, that all preparations must be made in peace-time. These preparations include military time-tables, train diagrams,* and tables of reference giving complete information as to station facilities and rolling stock available.

In recognition of his services, Capt. Panz (who had in the meantime been promoted Major) was appointed Chief of the "Department of Railway and Steamer Transport and Telegraphs," which was added to the War Office in 1865. This is our present Railway Division.

* *Note by Translator.*—A train diagram is a board with vertical scale of time and horizontal scale of distance, upon which the progress of each train is marked by a curve. Two curves may not intersect except at a shunting-point.

THE WAR OF 1866.

As a result of these measures, the war of 1866 found us less at sea, as regards railway matters, than that of 1859. Although the extent of our network of railways fell lamentably short of strategical requirements, yet it must be acknowledged that both the preparation and the execution of the transport of the masses of troops were adequately carried out, and that remarkably good results were achieved. 1866.

On the 15th March, 1866, the Railway Department received orders to draw up a scheme for the simultaneous concentration of the army in Venice, in Moravia, and in Bohemia. A month later everything was in readiness.

But since on political grounds it was desired to begin by concentrating the Army of the South, the whole scheme had to be withdrawn and revised. On the 25th April the railway mobilization scheme for the Army of the South was issued; that for the Army of the North followed on the 11th May. We must remember, however, that the amount of work which then had to be done was only one-tenth of that which the Railway Division is now required to carry out every year in the same time.

The transport by rail of the Army of the South began on May 1st and was completed by May 19th; that of the Army of the North began on May 20th and was completed June 9th.*

Even finer results were achieved by the railways, more especially the Imperial Northern and the Southern, at a later period of the war, when whole armies had to be transported from one of the two theatres of war to the other.

I will mention four instances, for details of which I have to thank H.E. Field Marshal von Beck, the Chief of the General Staff.

(1). Return transport of the 10th Army Corps from Lettowitz to Vienna (Mondel's Brigade to Lundenburg).†

In spite of the difficulties of entraining at the small and cramped station of Lettowitz, in spite of the pressure of the enemy and the severity of the weather, the railway transported the whole of the 10th Army Corps, together with several thousand sick and followers, within 38 hours in 20 trains.

(2). Return transport of the 3rd A.C. and part of the Saxon A.C. from Olmütz to Vienna.‡

From 9 to 10 trains per day were run, each of 200 axles or more, and in 3½ days the whole force had reached Vienna.

Great difficulties had to be overcome, due principally to the absence of returns of strength of troops to be entrained, the want of entraining facilities at Olmütz, the crowding and hurry which prevailed at the departure station, and the encumbering of the stations with masses of stores.

* In 19 days the Southern Railway conveyed, in both directions, 180,000 men, 8,500 horses, and 900 guns and wagons in 427 trains; average (one way only) 11 trains per day. In 20 days the Imperial Northern railway, into which the other lines converge, conveyed in one direction 200,000 men, 29,000 horses, and 4,500 guns, and wagons, in 458 trains; average (one way only) 23 trains per day.

† 22,000 men, 900 horses, 200 guns and wagons.

‡ 43,000 men, 4,000 horses, 700 guns and wagons.

Moreover the section Hradisch to Prerau was only a single line, and all trains had to stop for examination at the fortified enceinte of Olmütz.

In 1870 the transport of the Landwehr division of the German and Prussian Guard from Strassburg to Nanteuil took from the 7th to the 13th October, although the division required only 11 trains, totalling 750 wagons.

(3). Transport of the Army of the South from Verona to Vienna.

The 5th A.C.* commenced to entrain on July 9th at Verona, and was transported to Vienna in 47 trains *viâ* Innsbruck and through Bavaria, The section Bozen-Innsbruck, over the Brenner Pass, was unfinished, and had to be covered on foot by forced marches. The whole force was assembled in Vienna by July 22nd.

The remainder of the Army of the South † was railed *viâ* Görz-Marburg, Görz-Pragerhof-Ödenburg, and Villach-Marburg to Vienna and the neighbourhood. It was transported in 118 trains, and transportation completed within 14 days.

(4). Return journey of part of the Southern Army from Vienna to the Italian frontier.‡

This was accomplished with wonderful celerity and precision. Only 36 hours' notice of the move was given. Entraining began on August 2nd, and the whole move was completed within 15 days. The army was transported in 400 trains, the average number despatched daily being 26 to 27. Over the Semmering, where the trains had to be divided, as many as 80 and even 90 trains per day were run.

Lessons for the Future based on Events of 1866.

If I have devoted so much time to a description of the railway achievements of 1866, it is because I consider that the results then achieved form a standard by which we may gauge the railway performances of the present and of the future. But I am bound to point out that the rapid transfer of large bodies of troops by rail from one strategical area to another, as above described, is an operation which will only be possible during the later stages of a war. It would be rash to attempt such a scheme during mobilization, or during the concentration of the army at the theatre of war, when the capacity of the railways would be strained to the utmost in conveying men and materiel.

Whatever news of the movements of the enemy may arrive during this early period, it will be exceedingly difficult to alter dispositions once made for the initial concentration by railway of the forces. At the utmost, it will be possible to alter the stations at which the troops disentrain to other stations more advanced or more retired. Even this will give rise to serious practical difficulties, except perhaps in cases where each Army Corps has a line of rail to itself.

The events of 1866 made clear to all of us the importance of a well-arranged network of railways, and foreshadowed the increased importance which railways will play in future wars. The attention of all military nations was directed to the strategical possibilities of railways, and much attention was devoted to working out in peace-time the most complete plans for the utilization of the railways in war.

* 25,000 men, 3,000 horses, 300 guns and wagons.
† 60,000 men, 10,000 horses, 2,000 guns and wagons.
‡ 160,000 men, 21,000 horses, 3,600 guns and wagons.

THE FRANCO-GERMAN WAR OF 1870–71.

The difficulties which arose during the French mobilization form a most instructive lesson.

Railway Operations in France, 1870.

There was then in France no central controlling authority. That such must have been the case is shown by the fact that the French railway officials had to obey conflicting instructions from all sorts of different people, acting without any kind of concert or combination. Not only were these orders contradictory, but they were often cancelled and changed even while they were in process of execution. This soon resulted in confusion; the stations were choked with troops and stores, the available rolling-stock was not utilized to the best advantage, and the railway staff was hopelessly overworked without achieving any appreciable result.

It is, therefore, absolutely necessary to have all railway operations under the direct control of a strong central military authority. Failing this, but little is to be expected of the railways when mobilization is ordered. War is a business to be taken very seriously, and it is necessary for success to have all conflicting interests under control. This control can only be exercised by Army Headquarters.

No Regulations.

Besides the want of a central directing authority, the French in 1870 found themselves involved in difficulties owing to the want of Regulations for the transport of troops by rail in time of war.

The transport of masses of troops, which will have to be undertaken in future wars, requires most perfect organization, including the utilization of time, personnel, and materiel to the best advantage. This can only be secured by regularity in military traffic and uniformity in the loading of trains.

The French Railway Companies attempted to please the public as well as to obey the military authorities. As a result, the running-tables were unpractical and unsatisfactory to both parties. They had to be constantly revised, and proved, for this and for other reasons, to be very ill adapted to military requirements.

As regards the rolling-stock, there was no law in France which enabled the Government to "commandeer" rolling-stock when required. Any branch line might refuse to transport troops on the ground that it could not spare the necessary rolling-stock. No instance of such refusal is recorded, but the absence of power to give orders in such a case was one of the defects of the French system.

Entraining was in many cases delayed owing to the absence of ramps and docks for loading and unloading horses. This involved further disorganisation of the transportation system.

No attention had been paid in France to the requirements of railways as regards personnel in time of war. Many of the railway employés had to join the colours, so that the railway staff was actually reduced instead of being increased to stand the extra strain. The natural result was that the staff was unable to keep pace with the work. To repair the error, the French authorities ordered soldiers to be employed to assist the railway men in shunting and similar labour. But the soldiers neither liked nor understood the work, and performed it carelessly and lazily; this led to trains being blocked and even to collisions.

We in Austria have taken warning by these misadventures, and have so regulated the liability to military service of the railway employés that in case of war the railways will always have a full staff available.

Military Labour.

Should it be necessary to fall back on military labour to assist the railway staff, it ought to be sufficient, to ensure that the work is properly done, to impress upon the soldiers the extreme importance of securing smooth and rapid working of the railway. Once you get the soldier to understand that even greater results can be secured by the efficient working of the railway than any he could achieve with his magazine rifle he will no longer be found wanting in zeal.

Want of Preparation.

The working of the French railways in 1870 suffered not only from the absence of a controlling authority but from the lack of peace-time preparation.

On the 15th July, 1870, the railway companies concerned received orders (from the Minister for Public Works) to be ready *next day* to transport large masses of troops! It is difficult to understand how any intelligent person could have issued such an order. The time available for preparation was limited to a single night. The entraining actually commenced on the evening of the 16th; but by the 22nd the arrangements had broken down owing to deficiency of locomotives and drivers, and the movement of troops had to be suspended for several days.

During the days which followed, the railway authorities were frequently ordered to transport troops and the order afterwards cancelled. In some cases transport was ordered for infantry, and cavalry and artillery arrived at the station instead; these of course could not be conveyed in the carriages intended for infantry. Troops when already on the move to entrain found their departure countermanded at the last moment; and many similar contretemps occurred.

Owing to these mistakes, and to the fact that the regiments on arrival at the station varied very much in strength, some of the trains started nearly empty while others were overcrowded. Sometimes portions of units had to be left behind; no provision was made for taking them on with other troops, and the men finally wandered away and never rejoined. Thus, at the end of August, the railway station at Rheims was encumbered with several thousand of these lost sheep. These unfortunate occurrences not only interfered with the work of transportation but exercised a prejudicial effect on the morale of the Army.

These few instances are sufficient to show that strict discipline is an essential factor in the conveyance of troops by rail.

We may note here that although troops may suffer from the discomfort of long railway journeys in crowded carriages, this must be set off against the fatigues which they would have to endure for days in succession during a march by road.

French and German Results.

If, in spite of the difficulties above outlined, the French managed to transport 200,000 men, 30,000 horses, and 4,000 carriages to their north-eastern frontier in 14 days, this is to be ascribed to the completeness of their network of railways, the liberal equipment of rolling-stock, the shortness of the distances to be traversed, and the exemplary zeal of the railway personnel.

In the same period the Germans, although they had far greater distances to traverse, succeeded in transporting to their western frontier more than double the above number of men, horses, and wagons. This remarkable result was chiefly due to the perfection of their peace-time preparations, which were carefully thought out down to the most minute detail.

French Railways in German Hands.

But even the Germans did not get through the war without experiencing many difficulties as regards railway transportation. These occurred mostly during the later period of the war when they began to make use of the French railways.

Defects of German Organization.

Although it must be admitted that it was no light undertaking to take over the running of 2,500 miles of an enemy's railways, yet the chief cause of the friction which occurred was the defective organization of the German Field Railway Staff. The personnel were imperfectly acquainted with the special conditions under which railway work has to be done in war. No staff of technical experts, skilled drivers, etc., existed in peace-time, and there was no organization for the upkeep and repair of railway materiel.

In Austria we have taken this lesson to heart, and the result is embodied in our Regulations for the organization of field railways and for the Corps of Military Railway Men. We have, moreover, a special corps trained in the upkeep and working of railways, namely the Railway and Telegraph Regiment.

It is useful to study books of military history in which past events, as affecting the subject of railways in war, are described. I would particularly direct attention to a book published at the end of 1903, edited by the German Minister for Public Works (von Budde), and entitled *The French Railways under German Management, 1870–71*. I strongly recommend this book to all who in war will have to do with the military employment of railways.

I will now describe some of the difficulties which the Germans experienced in working the French railways in 1870–71.

Destruction of Railways.

In the first place, they found the permanent way damaged or destroyed in many places. As they advanced further into the country, and the hostility of the population increased, such instances became more and more common. In all, 78 large bridges and tunnels were destroyed and many miles of permanent way torn up.

Much time and heavy labour was required to repair these damages, and difficulties were experienced in obtaining building materials for the temporary constructions. In cases where tunnels or cuttings in even moderately unsound soil had been destroyed, it was found better to immediately lay a diversion than to waste valuable time in attempting repairs.

Raids on Railways.

Since 1870 railways have assumed so much importance as a means of offence and defence that in future wars the adversaries will be tempted, even more strongly than before, to undertake dashing raids with the object of destroying the enemy's railway communications. The importance of the prospective result will justify the acceptance of considerable risks.

It is therefore essential to discount the importance of such exploits, even if successful, by making preparations beforehand for the rapid repair of the line.

French Rolling-Stock Withdrawn.

Another difficulty experienced by the Germans in 1870–71 was the want of rolling-stock for the French railways of which they had taken charge.

As the French troops retired the railway rolling-stock had mostly been withdrawn, or, if this could not be done, had been destroyed. The facilities afforded by the small stations were scanty; the large stations, being within the enceinte of fortified towns, remained for many months in the hands of the French. The want of platforms and loading-docks caused delays which much impeded the military traffic and prevented the utilization of the available rolling-stock to its full capacity. In spite of constant reinforcements of engines and trucks from Germany, serious difficulties arose. The various Commanders had a way of seizing railway material when required for the movements of their own troops. They did not scruple to "commandeer" engines which had been detailed for the regular service of the line. These high-handed measures, though they relaxed the pressure at one point, seriously increased it at others; and it frequently happened that the regular train-service ordered by the directing authorities was brought to a complete standstill.

Our own regulations provide against these unjustifiable encroachments by local authorities upon the general strategical train service. But it will none the less be necessary to exercise strict supervision over the circulation of rolling-stock. This is one of the most difficult questions connected with the management of railway traffic in war.

Transfer of Rolling-Stock.

Another difficulty lay in getting the available rolling-stock to the places where it was wanted. It often occurred that portions of line captured from the enemy were cut off from the base, either because the line passed through towns in the enemy's hands or because bridges, etc., had been destroyed. In such cases it was necessary to haul engines and trucks *by road* from one point on the railway to another. The Germans had to overcome immense difficulties, and the history of the means which they adopted to surmount them is even now most instructive. For many of the adverse conditions of the Franco-German war will certainly be repeated in the future, although, with the assistance of our modern Railway Regiments, they will be easier to deal with. It is most desirable that our Railway troops should gain experience in peace-time of the transport of railway engines and trucks by road.

Locomotives.

Running conditions in war are very different from those prevailing in peace-time. Drivers and stokers are unskilled, unaccustomed to their engines, and strange to the line. The coal is often bad, and the engines are not properly cleaned and oiled, which seriously increases friction. There is no time to thoroughly inspect the trucks, nor to grease them properly. All these disturbing causes reduce the effective power of the locomotives by from 20 to 25 per cent.

Electric Traction. Compared.

While on the subject of locomotives I will say a few words about electric traction for use on main lines.

From the military point of view the following points require attention :—

The dependence of the system on one or more central power stations.

The liability to damage of the conductors.

The difficulty in replacing or supplementing the electric engines and their drivers.

If a central station is disabled, this stops the traffic over a long section, and it may take many days to re-establish it. Malicious or hostile damage to a power station must be reckoned with as a possibility, especially in the case of power stations near the frontier. Such an occurrence would have the most serious effect upon the mobilization and deployment of the army.

The same applies to the conductors, except that these are more easily destroyed and are exposed to damage at many different points.

Not only hostile acts, but accidents of all sorts, including lightning, storms, and heavy snow may disable the electrical system at any moment. How often we find our telegraph and telephone lines destroyed from these causes! Electrical power is therefore far less reliable than steam.

The use of electric locomotives on only a part of the railway system would render the whole railway system far less elastic and inter-supporting. And so long as electricity is used on a few lines only it would be most difficult to provide additional electric locomotives to increase the capacity of these lines in time of war. In view of the immense amount of capital sunk in steam locomotives and their accessories it will be long before they are replaced by electric tractors.

The partial introduction of the electric system would force us, on mobilization, to re-introduce steam on the electric lines, and this at a moment when all the railways would be worked to their utmost capacity. This, moreover, would involve a sudden change to a system unfamiliar to the lines in question and to their employés.

The only advantage of the electric system from a military point of view is that it requires fewer men to work it and possibly allows of a higher rate of speed for troop trains.

Before leaving the subject of the difficulties experienced by the Germans in running the French railways, I must refer to the trouble which they had with their railway personnel. Personnel.

Men to replace the French railway staff had to be imported in large numbers from the German railways. But as at that time the German railways differed considerably both in the nature of their equipment and the training of their employés, considerable friction arose when these men had to work together. The German railway men were taken from 26 different lines, and it took some months and a great deal of petty squabbling before they settled down to work together. This is one reason why the performances of the captured railways fell far short of expectations.

This was also due in part to the loose discipline of the railway men and to the friction which at first frequently occurred between the railway officials and the troops, leading to great difficulties and serious misunderstandings. These again led to friction between the different classes of railway employés, which, in the case of men of a too independent disposition, produced most undesirable results. To these sources of confusion must be attributed the fact that many railway officials of long-standing good character were guilty of serious offences of insubordination, indiscipline, and indolence.

Since those days we in Austria have done much to diminish the above difficulties by the establishment of a Field Railway Corps and the introduction of a uniform system of construction and signalling on all our lines. But difficulties will nevertheless inevitably occur, and much is still wanting to ensure that our staff of railway men in war will fall into line at once and work together. And the first essential for this is that they should be able to understand one another.*

THE RUSSO-TURKISH WAR, 1877–78.

1876. I will now consider the railway mobilization of the Russian Army in 1876, and the concentration by rail on the Turkish frontier in the autumn and winter of that year.

The transportation of masses of troops by rail had never before been attempted in Russia, and to this may be ascribed many of the difficulties that arose. These were so serious that, if Russia had been opposed to a powerful enemy concentrated near the frontier, the results would have been disastrous for her, and the neglect of the railways in peace-time would have been severely punished.

Russian Railways. The Russian network of railways existing in 1876 had almost all been constructed by private companies, who naturally built as cheaply as possible. The railways were laid out without any reference to military requirements and their equipment left much to be desired. They were nearly all single lines, built with steep gradients and sharp curves, and (especially in winter) were only suited for the running of short and light trains.

The stations were small, the sidings few and short. No wonder that the sidings quickly became choked.

The watering stations were too few and inefficient, the loading appliances defective, and the rolling-stock insufficient.

Russian System. The management of the railways in war was in the hands of a Central Committee, to which officers of the General Staff were attached as transport officers. The most important stations were under the command of Military Station Commandants.

Railway regulations for war existed, and there was a stock of equipment for the conversion of covered goods wagons to carry troops.

When, in 1876, relations with Turkey became strained and a partial mobilization seemed probable, the Committee, at the end of September, received orders to prepare plans for the mobilization and transport by rail of six Army Corps. Four were to move on Kischeneff, one on Odessa, and one on the Crimea.

But the Committee had only prepared plans for a general mobilization; so these plans had all to be revised, which took some time. Hardly had this work been completed, when, on the 24th October, the Committee

* *Note by Translator.*—Besides German, Hungarian, and Italian, 20 minor languages are spoken in Austria.

were informed that fresh alterations in the plans had become necessary. The mobilization scheme had to be worked out afresh, and, to cope with various difficulties that had arisen, the transport officers and the traffic managers were invited to a Conference at St. Petersburg.

The first outcome of this Conference was a circular, directing all lines to send in returns of rolling-stock available and to commence at once the construction of snow-guards to protect the lines from drifts. The railways were further enjoined to cease the acceptance of private goods from the moment of mobilization; all trucks then in transit were to be despatched to the stations where they were required on mobilization, and there unloaded. Finally, it was ordered that the Southern railways, which had most work to do, were to receive 572 locomotives from the Northern railways; but nothing was said as to when and where these locomotives were to be handed over. As will be seen, this omission was the source of much subsequent trouble.

The imminent commencement of mobilization rendered it necessary to close the Conference on November 14th before it had completed its work. This may perhaps be excused by the fact that this was the first time that the transport of masses of troops over the enormous distances of the Russian Empire had ever been attempted.

Mobilization began on November 17th. But within a week all military traffic had to be stopped, partly because the Odessa railway had run short of engines, partly because the Northern lines were choked with the engines and trucks intended to be taken over by the Southern railways. The Odessa railway could not take over the locomotives allotted to it, because the fire-boxes were constructed to burn wood while the Odessa railway used coal. Mobilization.

To evolve order out of the chaos created by their hasty and ill-considered scheme, the military authorities had to suspend the transport of troops for three days, November 24th to November 27th, and to postpone the eleventh day of mobilization to the latter date. This is a striking proof of the necessity for thorough peace-time preparation.

The sudden transfer of a large number of locomotives at a moment's notice caused considerable confusion, which could only have been avoided by the preparation beforehand of detailed and carefully-worked-out plans. Transfer of Locomotives.

We further learn from the experience of the Russians that it is most difficult to put strange locomotives on to a line unless the lines all use the same fuel. In this case the locomotives were of several different types, intended respectively for firing with coal, wood, petroleum, and heavy oil. To run them on other lines the fire-boxes had to be specially fitted or adapted, which took a considerable time and delayed the despatch of the locomotives. It is clear that in future special attention must be directed to uniformity of grate-construction.

The transport of troops to the base began on December 2nd. The plans for this transport had been issued on the 14th November (the first day of mobilization) in the following manner :—

Each Division received orders to send one officer of its staff to the nearest railway station to await orders. A messenger from Headquarters brought the plans for the movement of the whole Division, handed them over to the staff officer, and directed him to communicate them without delay to the units concerned. Army Corps, Districts, and Chief Transport Officers received their plans direct from headquarters.

But no sooner had the plans been issued than they had to be revised, partly in consequence of fresh movements of troops being ordered, partly in consequence of others being countermanded. The entraining arrangements had also to be modified, as many units were unable to reach their entraining stations on account of the snowstorms and the severe frost. These had therefore to entrain at stations nearer at hand, although without proper entraining facilities.

Transport of the General Staff.

Additional trouble arose over the incorporation of extra trains in the time-table. The greatest difficulty arose over the transportation of the Army Headquarters. The trains allotted to this service were timed so as to run at the period when the line was most fully occupied with the transport of troops.

Following the example set by the King of Prussia in 1870, it was at first proposed that the Army Headquarters should travel in troop-trains. But both on account of the cold and of the length of the journey this intention was abandoned, and special trains were run. I need hardly say that this entailed serious disturbance of the military time-table.

Water-Supply.

In the meantime a fresh contretemps threatened to stop the traffic. The water-tanks and hydrants at several stations on the Odessa line, where they were most required, became unserviceable, and trains were brought to a standstill. This block on the main line also affected the branch lines, which had to beg for a four days' rest as their stations were getting choked.

But in consequence of the unsatisfactory result of the previous three days' stoppage, this request was not granted, and the authorities merely reduced the traffic on the most overcrowded section, from Zmerinka to Birzula. To this end 55 troop trains were either struck out altogether or stopped at Zmerinka, where the troops had to disentrain instead of going on to their destination at Birzula. These troops were sent on afterwards by supplementary trains.

It may be imagined what confusion in the constitution of army corps and in the supply of the troops was caused by this proceeding. That no serious consequences ensued was due to the fact that the war did not beg n at once and that Turkey was unable to take the offensive.

Delays.

Many troop trains were delayed during mobilization and concentration, principally by the snowstorms which raged throughout Russia in December. Throughout the whole operation the railway traffic was much affected by the weather, which reduced the speed of the trains and delayed the march of the troops to the entraining stations.

But many of the delays were due to the unpunctuality of the troops in arriving at their entraining stations, owing to their not understanding the plans issued to them, and not appreciating the importance of exact compliance as regards the times laid down. Moreover, many of the units were ignorant of the procedure in railing troops in war. Some regiments demanded trains entirely composed of passenger carriages and others required the trains to stop at stations for as long as suited their own convenience. This was due to the troops having never been practised in entraining in peace-time.

Owing to the extreme cold of the weather the Russians found it necessary to arrange for special fittings for the covered goods wagons for the troops. It was at first proposed to cover the floors with straw and to lay straw mats on this; but although this was found by experiment to be satisfactory, the plan was abandoned on account of the danger of fire. The straw was therefore replaced by felt, which answered very well. Later on, as the cold became more severe, the railway companies, on their own initiative, either fitted several wagons of each train with stoves, or arranged for the attachment to each train of a third-class coach with warming apparatus. This rendered it possible for the men who were being frozen in the covered wagons to take it in turns to get warmed. Warming Appliances.

Further, the railway companies provided at their own expense tea, rum, and wood for camp fires for the men. The last in particular was a great boon to the troops, who often had to make a march of several days to the railway and to entrain at a station far from any habitation.

Similar measures were adopted on the Trans-Siberian railway during the recent war. The walls and floors of the covered goods wagons were covered with felt, with a layer of boards over; glass was fitted to the window openings, and a stove erected in each wagon. Buckets were provided in case of fire.

To make the long journey as easy for the troops as possible, special measures were adopted. The covered goods wagons were provided with planks, which could be so arranged as to allow from 28 to 32 men* to lie at full length all night.

Arrangements were also made to serve out boiling water from time to time to make tea, for which purpose a kitchen wagon was attached to each train.

THE GRÆCO-TURKISH WAR, 1897.

A striking example of the evils arising from want of peace-time preparation is afforded by the experience of the Turks in 1897. The confusion which occurred would certainly have led to disaster but that the Greek forces were inferior and unfit to take the offensive. 1897.

The Army Corps transferred from Asia Minor to the base had been allotted the line Muratlue-Feredjik-Badoma-Saloniki. This line was but poorly equipped for the transport of a mass of troops, and the small station of Muratlue, where they had to entrain, was utterly unfit for the purpose. It had accordingly to be rebuilt and enlarged, partly before and partly during the operation. The result was that of 72 battalions to be transported the last did not get off till a month after the first had started!

In spite of this very deliberate despatch of the troops, the line was

* The covered goods wagon usually holds 56 soldiers.—*Translator.*

repeatedly blocked, more than once for several days at a time. No preparations whatever had been made; rolling-stock was lamentably deficient; the railway employés were few in number and untrained; and finally, the section Feredjik-Badoma was very badly laid out. To get over this section the trains had to be divided; this seriously delayed the traffic (it was not unusual for trains to be two days late), and the line was often blocked with trucks for days at a time.

This accounts for the small number of trains despatched, which never exceeded 6 per day. Even that number was only occasionally attained. Sometimes for a week at a time only 40 trucks per day could be despatched.

Strong Measures applied by Turkish Government

But the Turkish government adopted summary measures for putting a stop to this state of things. This was due principally to the two accidents which occurred on the night of the 12th—13th March. The first of these was a collision between two trains near Jenikoi; the second the collapse of a bridge at Saloniki, by which a troop train was precipitated into the Vandar river, causing great loss of life and materiel. The Sublime Porte then telegraphed to the railway company that unless their line were set in order at once it would be confiscated. The effect of this salutary measure was that the railway company immediately set about borrowing efficient locomotives and trained men from other lines. Within 3 days they were despatching 125 wagons per day.

Another serious accident took place on the 30th March. A train ran off the line on the difficult section between Feredjik and Badoma, and blocked the whole line till April 15th.

Inaction of Turkish War Office.

The above difficulties were due principally to the characteristic methods of the Turkish military authorities. They did not concern themselves about the details of the transport of troops; they left all such matters in the hands of the railway and steamship companies. These companies were allowed to fix the amount of transport provided, the time of transit, and such matters, at their own convenience.

At the end of February a committee of Generals to supervise railway transport was formed in Constantinople. As however they had no information about the construction and equipment of the railways, or about the amount of rolling-stock available, their functions were merely nominal.

CONCLUSION.

It is a matter of the highest national importance that, in the hour of danger, we should be able to mobilize our troops and convey them to the threatened frontier as quickly as possible. To effect this we must bear in mind, in the laying-out and construction of our railways, the military necessities of the nation. Our people must understand that any neglect in organizing our railways for war becomes a matter of grave national danger. And finally, our railway companies must appreciate and understand their duty, so that at the critical moment they will act in concert, on their own initiative, for the defence of our country.

The effect of railways is to expedite the decision of the issue of war. May this great fact be fully realized in framing our military plans! And may the great body of railway men look forward with ever-increasing enthusiasm to sharing the duties of our Army in the protection of our homes!

May we never forget that to ensure victory we require not only an efficient army but a well-organized railway system; not only well-trained officers and soldiers, but highly-skilled and zealous railway men.

I cannot better conclude my lecture than by quoting the words used by the Prussian Minister of Railways regarding the railway mobilization of 1870:—"And our railways, too, have borne their part in achieving the glorious victories of our Fatherland."

NOTICES OF MAGAZINES.

Bulletin of the International Railway Congress.

November, 1906.

Suburban Traffic.—Two reports, by Mr. Drury of the G.E.R. and Mr. Sullivan of the Illinois Central, formed the basis of a discussion at a Congress Meeting. These showed that just as the conditions were in many respects different in Europe and America differing methods were adopted to meet them. It is fairly clear however that, generally speaking, in Europe the pressure is greater because the increase of facilities is attended with greater difficulty. For all that it is only in recent years that the daily movement of population to be handled has really become intense.

The principal points round which discussion ranged were:—

(1). Maximum density of traffic workable—the best way of moving a sufficient number of trains on the line and the planning of timetables making provision for irregular running.

(2). Engine power and acceleration of trains, with which is involved the question of electrical working.

(3). Duration of stops and best arrangement of carriages to ensure rapid loading and discharge of passengers. Opinion seems generally to incline to side-door carriages with plentiful gangway space. The type of carriage brought out on the Illinois Central is now well known.

(4). Ticket issue and collection, and station arrangements.

Besides the general aspect of the suburban traffic question it must not be forgotten that in many places in and out working is much complicated by junctions, and of course the question of the most economical train workings, *i.e.* best utilization of rolling stock, is one always before traffic managers. These questions have to be solved according to local conditions in each case.

Electrical working seemed, generally speaking, to be successful, mainly perhaps because of the ease with which a more frequent service can be maintained and the possibilities of economically varying the output of power. In America electrical trains are, it is stated, being run with less staff than those driven by steam. One American speaker asserted that generally in that country the workers went out of town to their employment instead of the reverse as here, but it seems rather a sweeping statement.

January, 1907.

SCREW AND CRAMP FASTENINGS FOR PERMANENT WAY.—Much attention has been paid of recent years to the strengthening of the road to resist the wear due to increased speeds of trains, and elaborate investigations have been conducted into the behaviour of the road under the moving load, so that by this time the nature of the movements which take place is pretty well known. Little seems as yet to have been done, however, to investigate exactly the conditions under which the various component parts of the permanent way do their work.

The article under notice, after remarking on the various stresses set up by the moving load, points out that one of the sources of weakness which most seriously needs to be combated is the tendency of the fastening between rail and sleeper to work loose. Practical experience has certainly shown that screws are much more satisfactory as fastening between rail and sleeper, at all events in the case of Vignoles rails, than any kind of spike.

With a view to improving the design of such screws the article proceeds to investigate the forces which cause screws so employed to work loose. It must be remembered that the screw, bearing as it does at one side only on the foot of the rail, has not to resist a direct drawing force but a force applied at one side and at an angle to the direction of the core. An analysis of the reactions shows that but a small portion of the helix does useful work, and indeed that the reactions developed from a large portion of the surface actually tend to loosen the screw. The next step then is to determine whether any alteration in the design would produce more useful working surface and diminish the disadvantageous portions. This line of investigation does not, however, lead to anything satisfactory; the theoretical design would not be practical.

It is then for consideration whether some modified fastening would not be an improvement on the screw. I should at this stage remark that the author is more especially considering the attachment of a rail to a steel sleeper, but his arguments would apply equally to a wood screw so far.

The result of the examination is to propose the use instead of a screw of a cramp, *i.e.* a fastening which will grip the foot of the rail with its head, its shank passing through the sleeper and its foot bearing with sufficient surface on the underside, the tightening up to be effected by a wedge passing between the foot of the rail and the upper surface of the sleeper. There seems to be much in the idea, the wedge and screw are of course the same nature of tightening arrangement applied in different ways. The precise pattern of the fastening is not discussed, however, and one sees certain practical difficulties, so that experiment would doubtless be necessary to ascertain the best design. The use of wedge or cotter fastenings ought not to be inimical to rapid laying.

C. E. VICKERS.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

January, 1907.

RECENT PROGRESS IN AËRIAL NAVIGATION.

A lecture by Colonel J. D. Fullerton, late R.E., which is too full of details to be adequately dealt with in a notice.

Dirigible Ballooning.

The chief characteristics are:—

1. The weight of the whole machine is supported by a balloon or bag filled with some gas lighter than air (hydrogen being the most suitable), so that no power is required to support the apparatus.
2. Forward motion is obtained by means of a motor actuating a propelling instrument, in the same way as in a steamship.

The author deals severally with Constituent Parts, Forces acting on the Balloon in Flight, Stability (longitudinal and transverse), Power required for Propulsion, Balloon (or envelope), Ballonet, Gas, Jacket (or net), Suspension Apparatus, Car, Fuel, Motors for Propelling, Steering (horizontally and vertically), Stability Apparatus, Rising and Landing Apparatus, Storage House, and Miscellaneous Fittings (*e.g.* searchlights and photographic stores).

As regards the *Envelope*, since a considerable proportion of the air resistance is due to the envelope, it is of great importance to make it "fair shaped." A spindle (or torpedo) form, with a ratio of length to diameter of about 6 to 1, the maximum diameter being about $\frac{1}{3}$th of the length from the front, appears to give the best results. Skin, as used in the British service, is the best material; but it is expensive, and foreign countries use silk or cotton varnished with some sort of india-rubber solution.

The *Ballonet* is a small balloon, filled with air, which is placed inside the main envelope in order to keep it tight and in proper shape. An air pump in the car regulates the pressure in the ballonet, which in its turn increases or lowers the pressure of the hydrogen in the balloon and thus enables the proper shape to be maintained.

Longitudinal Stability presents one of the great difficulties in connection with dirigibles. The various forms of apparatus for controlling it are:— (*a*) Rolling Weights; (*b*) Liquid Balances, consisting of tanks of water, usually one under the forepart of the balloon and one in the rear, in which the water is alternated by a pump in the car, the pump being put in action by a pendulum which starts it working whenever the inclination of the balloon exceeds a certain amount up or down; (*c*) Adjusting Planes, fixed fore and aft; and (*d*) Fish Tails on the principle of the tail of an arrow.

Rising and Landing.—The former is controlled by utilizing the ascensional force or by using special adjustable aero surfaces, and the latter by the last-named fittings. These purposes can, of course, be effected, when necessary, by throwing out ballast and letting out gas.

Details are given of the *Principal Types* of dirigibles,—the French "Santos Dumont No. 6" and "Lebaudy I. and II.," the German "Zeppelin I. and II.," and the "Italia." The "Santos Dumont No. 6," in October, 1901, succeeded in making a tour round the Eiffel Tower from the Parc d'Aerostation at St. Cloud, the distance of 16 kilomètres being covered in 29½ minutes, the velocity approximating to 20 miles an hour. The "Zeppelin" balloon is remarkable for the material of the envelope (aluminium) and its shape (cylindrical with conical ends); also for its great size, No. II. being 410 ft. long and 38 ft. in diameter. In October, 1906, No. II. manœuvred over Lake Constance, rising to a height of about 450 ft. and attaining a velocity of nearly 30 miles an hour.

Flying Machines.

These are of two kinds, viz. Soaring and Driving; the former are never likely to be useful in practice. The chief characteristics of Soaring Machines are:—

1. The weight is supported by the pressure of the air on a part of the machine called the 'sustainer.'
2. Motion in any direction is obtained by combining the force or the weight with the resultant air pressure on the whole machine. No artificial power is required.

The chief characteristics of Driving Machines are:—

1. Weight supported by 'sustainers.'
2. The motion in a given direction is obtained by a propelling instrument worked by a motor.

The author again deals with the various points enumerated above under the head of Dirigible Balloons. He recommends the construction, at present, of three sizes:—

Load.	*Weight.*	*Velocity.*	*I.H.P.*
1 passenger	800— 1,000 lbs.	30 miles an hour.	20 —25.
2 passengers	1,000— 1,500 ,,	35 ,,	25 —35.
4 passengers and 1,500 lbs. of stores	7,000—10,000 ,,	35—40 ,,	250—300.

The large type would be suitable for military reconnoitring work, and would carry a light gun for use against hostile machines and a special gun with heavy shells for use against ships or troops.

Sustainers are of two classes, viz. single surfaces and superposed surfaces. The former are large flat or curved surfaces formed of varnished cloth or canvas on steel framework, great care being necessary to make them airproof. The superposed surfaces are usually very narrow and fixed one above the other, the best material apparently being wood.

Oil or Spirit Engines seem at present to be the best for aeronautical propelling work, being comparatively light and economical in fuel, the fuel moreover requiring little stowage room.

Propelling may be done by (*a*) Jets, (*b*) Paddles, or (*c*) Screws. The two first forms are unsuitable for aeronautical work. Screws may be of the wing (or bird) class or of the ordinary marine type, the latter being the best.

Stability is effected by aero surfaces controlled by springs, pendulums, etc. As in balloons the main point is to have the centre of gravity well below the centre of pressure of the whole construction.

Rising and Landing.—For rising inclined planes or springs are used; but the true flying machine is one that can rise by its own unaided power. The best plan comprises specially prepared smooth rising tracks, along which the machine can run under its own motive force, actually rising when the velocity required to produce the necessary lifting power has been reached.

Some particulars are given of the *Principal Types* of Flying Machines,—the Maxim, the Phillips, the Langley, and the Wright,—but information as to details and trials is difficult to procure. The Wright machine, in October, 1905, made a circular trip in the air of some 36 minutes duration and attained a velocity of 40 miles an hour. Other inventors engaged in this science are Santos Dumont, Bleriot, de Vaux, and Vuia.

Present Position of Aeronautics.

The author considers that *Dirigible Balloons* do not seem a satisfactory solution of the problem of flight. They must be of considerable size to carry any reasonable weight; their speed is limited; there are many difficulties in construction and management; and, contrary to the popular idea, they cannot rise or descend at any time and anywhere, but require a land harbour.

Flying Machines appear to present the best solution. There is now no reason to prevent the construction of good serviceable machines to travel at 30 to 40 miles an hour; and their cost, omitting experimental expenses, need not be more than that of good motor cars.

In War Flying Machines will be regularly employed in the future against other airships and against sea and land forces. For purely aerial warfare both sides will maintain high-speed machines, armed with light guns, and well supplied with fuel so as to possess a large sphere of action. Against ships Flying Machines will be useful for reconnoitring, especially of submarines, and for dropping projectiles on to decks. (In regard to reconnoitring the lecturer quoted the Rev. J H. Bacon, who, in a voyage across the Irish Channel, took photographs which clearly showed rocks, sand, etc., under 60 ft. of water; and in the subsequent discussion, Colonel J. E. Capper, R.E, related how, when passing recently over the muddy waters of the Medway, at a height of 1,500—2,000 ft., he could clearly see the tortuous channels and could easily have directed a ship's course). Against land forces they will be used principally for reconnoitring, but will also be effective in other ways such as setting fire to store depôts. (In this connection we may refer to a thrilling story in the January *Blackwood*, in which a brother officer, 'Ole Luck Oie,' describes how the repairing of an important bridge, on which depended the further fighting power of an army in front, was frustrated, almost at the very consummation of weeks of arduous labour, by a mosquito fleet of air-ships).

In Commerce the lecturer sees an opening for postal and light parcel work, and thinks that it will be quite possible to carry passengers and light goods at remunerative rates.

In conclusion Colonel Fullerton urged the appointment of a Royal Commission to consider the whole subject of aerial flight; and we believe that, with the lead of the Aeronautical Society of Great Britain, an association has just been formed for this purpose, the committee of which includes Colonel Fullerton and Colonel Capper.

ORGANIZATION WITH SPECIAL REFERENCE TO PREPARATION FOR WAR.

An anonymous writer 'communicates' a most valuable essay, which everyone should read in the original.

He commences by remarking on the corrupt and illegitimate use of the word 'organization.' Its most important correct meaning denotes the science that deals with the principles under which a body or agency is furnished with organs having special functions, mutually dependent, and all essential to the healthy life of that body; a secondary meaning refers to the application of this science to a particular body or agency. The word is erroneously used, instead of 'organism,' to denote the body itself; and instead of the words 'preparation,' 'arrangement,' 'plan,' etc., which signify the attainment of a certain purpose by means of the agency and not the formation of the agency itself.

All alterations in military organization are due to an attempt to forecast the future, to improve on the past, and, with the knowledge of recent experience, to adopt changes that will produce better results than before. The author discusses how such changes conform to the principles of organization, of which he chooses the following for consideration :—

1. Definition of Object or Purpose.
2. Sufficiency of Material.
3. Proportion of Parts.
4. Relation of Parts.
5. Necessity of Central Control.

1. *Definition of Purpose.*

A clear idea must first be formed of the object for the attainment of which the organism exists or is to be created. Sometimes there is more than one object involved: when they do not conflict the more important usually include the less; when they differ a compromise becomes necessary.

In military organization this principle is frequently ignored. France, Germany, Switzerland, and Japan are nations that organize their military forces in accordance with this principle; in our case it is only recently that proper attention has been paid to it with regard to our Regular Army, and it has been almost entirely neglected with reference to our Auxiliary Forces.

The conditions of our Empire render it impossible to state the purpose for which our Regular Army is required, or the conditions under which it will take the field, with such exactitude as can be done by the other nations mentioned. But success in war depends upon complete preparation in peace, such preparation including the accumulation of equipment in precise quantities for units whose exact war strength must be known to all concerned. Our naval supremacy will not secure us time to complete our preparations for war when the war comes upon us; and in the case of some great wars that are possible every hour's delay will imperil our success. The British military authorities have always worked upon a normal organization for service in a civilized country with a temperate climate. All other cases, some far more likely to occur, are treated as exceptional, because time would be of less importance and conditions cannot be definitely foreseen.

As for the Auxiliary Forces the only 'purpose' that has had any concern in our treatment of them is covered by the term "Home Defence." In attempting to establish more definite objects we were met with the conflicting argument of the 'Blue Water School.' Moreover, plans for Home Defence have been framed on the existing strength and condition of the Auxiliary Forces; they have been made to suit the composition of the forces instead of the forces being made to suit the plans.

If, however, for Home Defence we substitute Imperial Defence, we have at once a purpose common to all the services, from which the purpose of each can be determined.

2. *Sufficiency of Material.*

In armies raised on a system of universal service the available material, with certain exceptions and within certain age limits, consists of the whole manhood of the nation. The proportion between the strength of the army and that of the whole manhood may vary; but the principle of designing the organism to suit the available means is always observed.

In England the available material could be assessed as easily as elsewhere. Under our voluntary system, however, it is not all available. In the Regular Army the principle is observed, for conditions of enlistment, pay, and service are varied until the requisite numbers are obtained. In the Auxiliary Forces, however, though every man can be called out in the extreme emergency of an invasion of Great Britain, we cannot even estimate the number of men on whom we can rely for service over sea,—it may be anything from 1,000 to 300,000; under these circumstances organization is impossible, because the principle is disregarded.

3. *Proportion of Parts.*

This is frequently overlooked, or recognized only with reference to comparatively minor details such as the number of guns to bayonets. But it must be studied, not only with regard to the strength of the various combatant arms, but also in the composition of every unit, whether combatant or administrative, which is required for service from the base to the outposts of an army in the field.

With our Regular Army this principle has usually, though not always, been observed. In the Auxiliary Forces the sense of proportion has been conspicuously absent, so that we have now an excess of some 20,000 of garrison artillery whilst some of the essential administrative services are entirely non-existent.

Naturally, and perhaps rightly, strategy and tactics attract most of the attention of military students; and the meagreness of peace establishments, coupled with imaginary units in manœuvres, is a contributory cause of the neglect of the principle of proportion of parts.

The value of an object lesson in organization, as against the false impression produced by half-formed units, suggests the advisability of completing a portion of manœuvre troops to full war establishments as was done last year in France.

Army Corps have recently been abolished, and enlarged Divisions have been established as the only independent, self-contained, and self-supporting fighting bodies. In the Field Army as now organized (viz. 1 cavalry division, 2 mounted infantry brigades, 6 divisions, and 1 line of communication) there are no less than 472 units of 68 types. Each type is a separate organism, designed so that it may fulfil its duties to the best advantage of the whole force. The new "War Establishments," which show the complete war organization of the Expeditionary Force, deserve to be studied in detail.

4. *Relation of Parts.*

This is just as important as the number of parts. Each part must be considered with reference to the common purpose of the whole body,—success in war. Each must be organized, not only to perform its own functions, but to assist others and to contribute through them as well as by itself to the common objects; this is called 'co-operation.'

The principle applies to the interior composition of the smallest individual unit as well as to the larger organisms; and in some cases (the battery) it is more important than in others (the company).

5. *Necessity for Central Control.*

However carefully a particular body may have been organized it is incomplete and ineffective without a directing and controlling power. In military organizations, though the will of the supreme commander must be communicated to every part of the body, command cannot be exercised efficiently over more than some half-dozen subordinates. It must therefore be delegated; and this delegation, from link to link in the chain, is the organization of command and is subject to the same principles as in the case of other organisms. The transmission of will power is the function of the staff, whose purpose is to facilitate it; the staff system must be coincident with the command chain, and is part of the organism of command rather than an organism itself.

The Expeditionary Force.

The author then proceeds to examine how the above principles have been followed in the recent organization of an Expeditionary Force, the leading features being :—

(1). The increase of harmony in the relationship of the component parts.

(2). The strategical freedom attained by the Independent Cavalry.

(3). The establishment of the Division as the only independent fighting unit.

(4). The modifications, principally in artillery and engineer services, necessitated by recent experience and improved material.

(2). Cavalry must be prepared to defeat the enemy's cavalry whenever and wherever they are met. Formerly our cavalry brigades had the duty of protection as well as that of strategical exploration. The new cavalry division is set free for the latter task; and security is entrusted to the mounted brigades, each consisting of 1 cavalry regiment, 1 horse artillery battery, and 2 mounted infantry battalions.

(3). The Divisions are strategical units in the hands of the Army Commander. He disposes of the mounted infantry brigades as security troops in advance of the divisions, but he has no tactical functions with regard to the latter; and for this reason, no combatant force, other than the M.I. brigades, is included in the Army Troops, the infantry battalion and two squadrons of yeomanry being only for escort duties.

The new organization includes all the changes which have been approved in consequence of recent war experience and improved equipment. The most important concern the artillery and engineers.

"Judging from recent war experience in Manchuria and South Africa, the infantry attach greater importance than ever to the support of artillery fire, both in attack and defence. Not only is there justification for an increase in the number of guns, but it is also recognized that a combination of different classes of artillery fire will produce results eminently favourable to the action of the infantry. The shrapnel of flat-trajectoried field guns, the searching power of field howitzers, combined with the possible closer approach of the infantry under their steep descending fire, and the powerful shell of the heavy artillery, afford the means of producing greater effect, in the hands of a skilful commander, if employed in conjunction with each other than if they are treated separately. The allotment to the divisions of every nature of ordnance, except that of horse artillery, gives to the divisional commander the opportunity of using this enhanced effect to the fullest extent which the tactical conditions admit of, and to the greatest advantage as a whole of the division for whose action he alone is responsible. The additional personnel (orderly officers, range-takers, signallers, etc.) required to enable the artillery officers to use the whole of the combined artillery in furtherance of the wishes of the divisional commander is shown in "War Eastablishments." * * * The organization of the supply of ammunition, from the advanced depôt to the fighting batteries and battalions, is based on similar principles—viz., those of purpose, proportion, and relation of parts—which are, perhaps, better illustrated in the artillery than in any other arm of the service.

"The engineers are, perhaps, affected most by the new organization. The Manchurian War seemed to point to the necessity for considerable increase in the field companies for work in the fighting line. Allowance must, however, be made for the topographical and strategical conditions, which precluded lateral mobility to a great extent, and gave to the principal battles the characteristics of siege rather than field work, due to the frequent necessity for direct frontal attack. It is not, therefore, in this direction that we find most change.

On the other hand, this war fully confirmed what had been long known, that a development of the communication service is absolutely essential. Army headquarters now have two cable, two wireless, and two air-line telegraph companies; each division has its own telegraph company; while two are allotted permanently for line of communication work.

The field companies will, however, be expected to do more work than hitherto, especially in connection with the construction of all the bridges that may be required for the army. The actual equipment, except a small quantity for minor crossings, is kept well in rear in two trains, so as not to hamper the marching columns when not immediately required. This is in conformity with a general policy, which has been applied to the whole Army.

The inordinate amount of transport, which formerly accompanied the troops, tended to interfere with their mobility so seriously that their value as fighting bodies was considerably impaired. Transport has accordingly been reduced; so that the front line troops now only carry with them what is essential for fighting efficiency and health and to render them independent in these respects for a short period of about a fortnight. All else is put further back in the line of march, its distance in number of days of march from the front depending on the frequency and probability of its being required."

A. T. MOORE.

REVUE DU GÉNIE MILITAIRE.

December, 1906.

THE SIEGE OF PORT ARTHUR.—A review of a pamphlet published by the German General Staff. It appears from internal evidence that the writer of the pamphlet was not in possession of any more information than has already been made public. For this reason the chief interest of the work lies in the 'appreciation,' given by the German General Staff, of the siege as a whole.

"The Japanese artillery," writes the German author, "was not employed according to modern principles. At the commencement no attempt was made to destroy the Russian guns; but the artillery fire was dissipated on the harbour, the town, and the whole of the enemy's positions. Consequently the assaulting columns suffered much from the flanking fire of the Russian artillery." The French reviewer points out, however, that it was the Japanese artillery fire that drove the Russian fleet to make its unfortunate sortie on August 10th; and that it was machine gun, not artillery, fire that decimated the Japanese assaulting columns. For these reasons the German criticism seems hardly justified.

The German General Staff despises mining. It is confident that, if the besieger has enough artillery and infantry, mining will be unnecessary. The French reviewer does not agree with this opinion. He points out that the Japanese did not commence mining until after their superiority in infantry and artillery was overwhelming. On the other hand, the Russians, if they had prepared an efficient system of counter-mines, could have arrested the advance of the Japanese saps, and compelled the besiegers to mine through hard rock, thus prolonging the siege.

In spite of the very partial success that attended the Japanese general assaults, the German General Staff is still in favour of this system of attack. In the face of much evidence to the contrary, all the failures at Port Arthur are attributed by it to insufficient artillery preparation. "It may be anticipated therefore," writes the French reviewer, "that in the next war a general assault will be a frequent preliminary to the step-by-step attack. An energetic defence will always compel the besiegers to adopt the slow methods of a regular siege."

DIRIGIBLE BALLOONS.—A continuation of the previous articles. Of historical interest only.

January, 1907.

DIRIGIBLE BALLOONS.—The continuation and conclusion of the previous articles on the subject. As the authors make no mention of any of the balloons that have been constructed since 1903, the treatise is very far from complete.

J. E. E. CRASTER.

REVUE MILITAIRES DES ARMÉES ÉTRANGÈRES.

November and December, 1906.

THE RÔLE OF THE GERMAN FORTRESSES.—Of late years there has been a great increase of permanent fortifications in Germany. This cannot be attributed to any intention on the part of the German General Staff to abandon the offensive. As the result of a careful study of German strategy, the writer has come to the conclusion that the fortresses lately constructed along the German frontier are to fulfil two rôles. Firstly, they will form a screen behind which the mobilization and concentration of the field armies will take place; it will thus be possible to mobilize and concentrate near the frontier without fear of interruption. Secondly, in the event of a war against both Russia and France, the German armies will be numerically inferior to their opponents, and may find it necessary to adopt an offensive defence of the Franco-German frontier; the fortresses will then form strong pivots about which the field armies will manœuvre.

J. E. E. CRASTER.

RIVISTA DI ARTIGLIERIA E GENIO.

November, 1906.

OPERATIONS AROUND PORT ARTHUR IN 1904.—By Capt. Luigi Giannitrapani.—Twelve years ago, or in November, 1894, during the war between China and Japan, the Japanese army besieging Port Arthur consisted of 18,000 men under the command of Marshal Oyama, with General Nogi in command of a brigade. The defences on the land side were incomplete, and protected only the eastern and southern sides, where the Chinese had 12,000 men. On the 20th November, Oyama gave orders to attack the southern front; the Japanese artillery opened fire against the two redoubts, one of which was blown into the air at 10 o'clock in the morning and was immediately occupied, whilst the other was carried by assault an hour afterwards; and the following day the entire place fell into the hands of the Japanese.

But the operations around Port Arthur ten years afterwards were of a very different character.

We may be able to divide these operations into various periods each having its special characteristics.

From the commencement of hostilities until the end of May the operations were entirely between the fleet and the coast batteries; at the end of May the battle of Nansan, which ended in a victory for the Japanese, definitely closed the communications between the fortress and Kuropatkin's army, and the land operations may then be said to have commenced.

The first period of the latter embraced the months of June and July, and included on the part of the Japanese the conquest of the land between Dalny and Port Arthur, the fighting for the advanced defences held by the Russians, and finally the complete investiture of the fortress.

The second, during the month of August, is characteristic of the attempts to capture the place by heavy infantry attacks which failed against the obstinate resistance of the Russians.

The third includes the months of September and October. Failing in the hope of capturing Port Arthur by direct assault the Japanese commenced regular siege operations, varied by local general assaults which brought about the capture of the advanced works of the place.

Finally, in the fourth and last period, mining was resorted to, and direct attacks from close quarters led to the final capture of the fortress.

COMMENCEMENT OF THE LAND OPERATIONS—BATTLE OF NANSAN.

After the battle of the Yalu, and after the Japanese fleet had established an effective tactical blockade in the waters of Port Arthur, commenced the disembarkation of the troops whose duty it was to isolate the fortress on the land side. The army was under the command of General Oku, and was composed of 3 divisions which disembarked successively without opposition from the Russians on the tract of coast near Pitsevo. About the 6th May the Japanese succeeded in interrupting the railway near

Pulianten, just after the train had passed which carried the Viceroy Alexieff on his way to Mukden; but on the following days the communications were re-established so far that on the 8th May a train charged with ammunition was able to enter Port Arthur.

The army of General Oku effected its disembarkation, and was concentrated near the isthmus of Kinchow, which is closed in by the well-known hills of Nansan that constituted the true key to Port Arthur. On this position there should have been a fort to prevent the disembarkation, but unfortunately for the Russians it had not been erected.

The position was indeed formidable both by nature and by art, being almost flanked by the sea, and dominating the plain which had to be traversed before a frontal attack could be made. It was occupied by an entire division.

On the 26th May, after an obstinate struggle lasting from dawn to sunset, the Russian position was taken in flank by the fire from the Japanese guns, and was captured.

The Russian troops retired towards Port Arthur, while the Japanese army during the following days seized the positions of Talienwan and Dalny, thus acquiring an excellent base for disembarking their siege material.

On the 2nd June the advanced guards were only 25 kilomètres from Port Arthur, facing the Russians who had occupied and fortified a long line of defences across the Kuantung peninsula, in which they proposed to make as long a stand as possible in order to gain the necessary time for the systematic defence of the fortress.

In the meantime there took place at Dalny the disembarkation of the troops and materiel to complete the besieging army. General Oku's army was moved north against an offensive movement under General Stakelberg with a view to relieving Port Arthur from investment.

ADVANCE OF THE BESIEGING ARMY DURING JUNE AND JULY: DEFENCE MADE BY THE RUSSIANS OF THE GROUND IN FRONT OF THE PLACE.

The Japanese Besieging Army, during the month of June, occupied gradually a long line, about 25 kilomètres from Port Arthur, across the Kuantung peninsula. Thus it covered the railway and the port of Dalny, and with such means of assistance it was able to concentrate quietly the work of collecting materials for the siege. Meanwhile steps were taken to clear the neighbourhood of Dalny of mines, so as to permit of the free ingress of ships.

On the Russian side, General Stösell, on account of the unfavourable condition in which he found the fortress, continued to hold ground as far distant as possible and contested it step by step. He thus achieved the double object of gaining time for the reinforcement of the principal works, by the construction of advanced works in which the place was still deficient, and of weakening his adversary before he came within the zone of action of the forts.

The position taken up with this object by the Russian 4th Division after the battle of Nansan consisted of a series of advanced posts, situated from 15 to 20 kilomètres from the fortress, from which it was well able to dominate the Japanese lines; and behind this position there was a line of heights fortified by field entrenchments which barred an advance from the east. The left wing of the position, evidently the most important, was specially strengthened and was furnished with electric search lights.

The two contending lines thus found themselves at a short distance from one another; and combats of advanced posts, in which some of the Russian ships from Port Arthur were also engaged, took place during the whole of June.

On the 26th June, ten days after the battle of Wafangu, the Russians had lost all hope of succour from the north, and the Japanese Siege Corps commenced to advance.

The right wing (1st Division) remained in its position near Antzushan; a central column advanced towards Pantau; and the entire left wing (11th Division) was directed against the front Pantau-Waitoushan-Shuantinshan occupied by the advanced Russian troops. The heights of Pantau were occupied by the Japanese in a comparatively easy manner, but their left wing met with obstinate resistance so that it was only in the evening that it was able to occupy the enemy's positions as far as the heights south of Kienshan.

The advanced Russian troops retired farther south to Laotushan, on the extreme right of the position occupied by the 4th Division, where they threw up field entrenchments.

The Japanese remained on their new front Antzushan-Shuantinshan, where they rested another month until the 26th July. During this period they brought forward their siege material, and awaited the 9th Division and the 1st and 4th (Kobi) Reserve Brigades which were disembarked in succession. But in the meantime they had to suffer a vigorous counter-attack from the Russians.

December, 1906.

OPERATIONS AROUND PORT ARTHUR IN 1904.—By Capt. Luigi Giannitrapani, Captain of Artillery.

COAST DEFENCES.

We have seen that in the operations round Port Arthur the small efficacy of the fire of ships against coast batteries has been fully confirmed. The losses in the Russian batteries were slight, both in matériel and in men. A Russian artillery officer, Judenic, who took part in the defence of the place, relates, in an article published in the *Eenzhenernee Zhoornal* of May last, that the masses of cement in the coast batteries were protected with sheet iron against splinters caused by the enemy's projectiles, but that such splinters did not really occur and the cement when struck resisted in the best possible manner. The sheets of iron, however, formed a good protection against the flames produced by the fire of the mortars.

The artillery duel between the ships and the coast batteries almost always took place at a distance of from 6 to 8 kilomètres. Considering the small results from the fire of the ships, it might be conjectured that such fire would be more efficacious if the ships approached nearer; but this is an erroneous hypothesis, since by diminishing the distance the angle of descent is also diminished considerably, and this decreases the vulnerability of the coast batteries, at the same time increasing the perforating power of the projectiles thrown from these batteries against the ships.

The effects of the bombardments of the Japanese ships against the city, the arsenal, and the Russian ships in the inner bay did not produce heavy material losses, although causing a certain amount of disorganization and panic, especially among the civil population. The action of the Japanese fleet, facilitated in a measure by the want of batteries on the Laotishan promontory, was brought to perfection by the employment of indirect fire, controlled by wireless telegraphy from an observing cruiser stationed at a distance. This became a real danger particularly to a place not exclusively military but containing also a civil population. The panic produced in Port Arthur was limited in its consequences owing to the civil population being small, so that grave disturbances on the part of the inhabitants, who were unable to influence the conduct of the defences, were restrained.

OBSTACLES, SEARCH LIGHTS, AND MINOR ARMAMENTS.

The operations outside Port Arthur from June to December, 1904, present many features for study. Among these may especially be noted the employment on a vast scale of certain technical measures, prearranged but improvised, which give to this siege a particular character.

Special mention may be made of barbed wire, an accessory means of defence certainly not new, but which by its very extensive employment by the Russians contributed greatly to retard the assaults of the Japanese infantry who had commenced to feel the nature of the resistance offered at the position of Nanshan. The wire entanglements were placed in all the works and trenches, and even the heavy shell fire did not succeed in destroying them. The Japanese tried several methods of overcoming these obstacles. At first they distributed scissors of a special pattern, in great numbers, and sent detachments of sappers, crawling along one by one, who, lying down near the wire, endeavoured to cut it; but frequently the wire was so thick that it was not possible to cut it by this means, and the Japanese officers reported that sometimes the men were so enraged at their useless efforts that they threw down the scissors and tried to break the wire with their hands and teeth, twisting and biting it until they succeeded in forcing a passage. Afterwards the Japanese tried to break down the entanglements altogether by cutting the posts that supported the wire; but this again failed, owing to the men being so much exposed to the enemy's fire. They then concocted a plan of covering from the enemy's view the men employed in breaking the obstacle. They filled long bamboo canes with black powder which created a dense smoke; the men carrying the canes stretched themselves on the ground close to the obstacle, and, setting fire to the ends of the canes, pushed them into the entanglement; the several explosions broke and destroyed the wire. The canes were also charged with guncotton and the black powder, setting fire to the guncotton, exploded the charges at the same time.

The Russians also made use of metallic wire charged with a current of 500 volts produced from a dynamo situated inside a fort. But this system also failed in its purpose, because the Japanese easily cut the wire with large pincers furnished with insulators.

Sometimes the Japanese, in full daylight, advanced against the obstacles protected by big shields. The shield was suspended from the shoulders of a man who advanced on his knees, thus progressing slowly; the bullets did not actually strike the man, but sometimes powerful shocks caused him to fall, and he could only recover himself with much difficulty. Afterwards lighter and more manageable shields were tried.

Among the various methods used for defence from night attacks the Russians, at the commencement of the siege, made use of electric search lights. These discovered the Japanese infantry advancing to the assault, thus causing them confusion, while at the same time the quick-firing guns and pompoms poured on the troops thus exposed a shower of shells. The correspondents who were present at the siege report that the beams from these lights were so powerful as to light up every part of the ground as though it was daylight. The Japanese seemed unable to make much advance under these search lights, which they considered one of the most formidable of the enemy's methods of defence. Much of the time of the advance was taken up in seeking for inequalities of the ground, between which the implacable rays of the search lights could not find them out, but after August they appear to have abandoned the great night attacks which characterised the first period of the siege.

Another method of the Russians for lighting up the ground was the employment of bomb stars. These gave a shower of white phosphoric light which completely illuminated all the ground below. The light coming from a height, and being of considerable intensity, left no spots of shadow, and no one could move in the illuminated zone without being discovered.

Mitrailleuses were also largely used by the Russians and with great success. These weapons could be carried by two men, their small size rendering their discovery difficult; the Japanese suffered from the terrible effects of their projectiles, and the Russians were able easily to repel the assaults of the enemy's infantry. At night the mitrailleuses were used with great effect with the assistance of the search lights, which discovered and confused the enemy.

The quick-firing guns of small calibre, with which the Russians were largely provided, had great moral as well as material effects on the Japanese.

That ancient weapon, the hand grenade, which had been relegated to historic records, was again brought prominently forward in this war at the beginning of the XXth Century, and we find it in use by both Russians and Japanese in the field operations during the siege. The soldiers had great faith in these projectiles, which they threw by hand by means of a kind of catapult. On the Japanese side the grenades were fired by means of very light mortars of wood, bound with bamboos, which were carried by two men following the assaulting columns. They were carried in baskets of willow twigs.

According to reports furnished by a Russian Engineer officer who took part in the defence of Port Arthur, the Japanese made use of a special kind of hand bomb, charged with prisms of melenite, which had a very powerful effect.

The Russians also made use of some large land torpedoes—some of great weight, as much as 250 k.g.—with slow matches lasting from 1 to 2 minutes, which they threw against the enemy, causing great panic and heavy losses. According to Japanese sources of information the Russians also employed naval torpedoes for their land defences.

Terrestrial mines, fired automatically by electricity, were also largely used during the siege. But according to Russian reports only 1·80 per 100 of these were successful, chiefly owing to the wires being broken by the enemy.

TRIALS OF THE HOLMGREN EXPLOSIVES.—Capt. Andrea Holmgren of the Swiss artillery has furnished the following information regarding the experiments carried out on the 23rd August, 1906, on an explosive of his invention. Trials were made with projectiles weighing 41 k.g., charged with 3·5 k.g. of the Holmgren explosive. Against an entrenchment at a distance of 3,900 m. the projectiles made cavities in the ground varying from ·50 to 1·20 m. in depth, and from 2 to 3·5 m. in diameter and breaking 20×25 c.m. beams which formed a covering for the trenches.

It was ascertained that projectiles charged with this explosive produced the same destructive effects as the explosives now generally used, while Holmgren's explosive has the advantage that in event of the bursting of the shell before it leaves the mortar no damage is caused to the gunners: this at least is stated by the author to have been demonstrated at the trials. The trials also proved that no splinters were thrown in a backward direction, so that no injury would be caused either to the gunners or to the guns or mortars in the case of the projectiles bursting immediately after leaving the mouth of the mortars.

Some shrapnel were fired with a quantity of such an explosive, but specially adapted to create an abundant smoke at the moment of bursting. They were fired from field guns against a target at a distance of 1,000 m. The shrapnel produced dense clouds of smoke, which in a few minutes concealed the target like a thick cloud, and in action it would have been possible to advance against the firing line without being discovered.

No communication has been made with regard to the composition of this explosive.

EDWARD T. THACKERAY.

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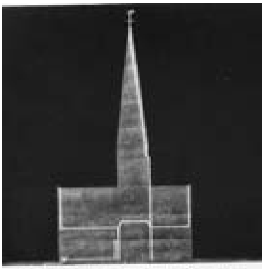

FIG. 1.—German Lutheran Church, Dalston, N.E.

FIG. 2.—Needwood Church, Staffordshire.

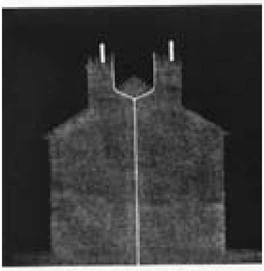

FIG. 3.—Type of Ordinary Small House.

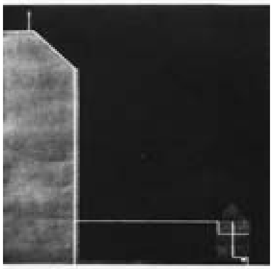

FIG. 4.—Corporation Granary, Bristol.

FIG. 5.—A Sussex Mansion.

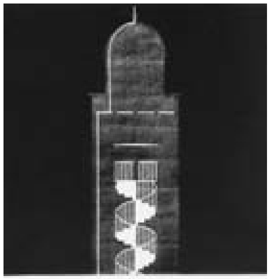

FIG. 6.—A Tower of Westminster Cathedral.

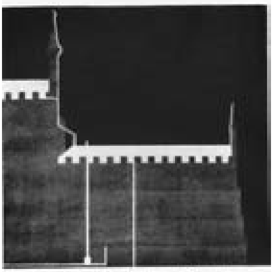

FIG. 7.—Lady Chapel, Gloucester Cathedral.

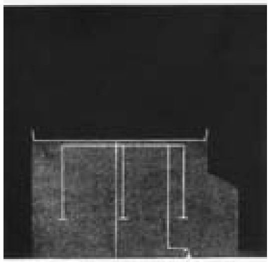

FIG. 8.—Type of Ordinary Large Hall.

Protection of Building