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MAJOR A. T. MOORE, R.E.

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PREFACE TO FOURTH SERIES.

THE following Preface to the first (January, 1905) number of the new series of the *Royal Engineers Journal* is reprinted here in order to explain the non-appearance of any volumes of the *Professional Papers of the Corps of Royal Engineers* for the years 1905 and 1906.

The *Royal Engineers Journal* was started in 1870 as a monthly newspaper for private circulation amongst subscribers; it was published by a Committee in London. At first it included a "Distribution List of Officers of the Corps," but from January, 1873, this List was printed separately as a *Supplement*. The *Journal* proper contained:—(1) articles on military, technical, and miscellaneous subjects, and (2) matter of a more or less private nature concerning the Royal Engineers and their various regimental institutions and funds. At the end of 1875 the publication was taken over by the Royal Engineers Institute, which had been founded early in the same year.

The *Professional Papers of the Corps of Royal Engineers* were commenced in 1837 for circulation amongst subscribers, and were also published by a Committee of officers in London. They included technical articles on subjects connected with the multifarious duties of the Corps, were issued in annual volumes, and were on sale to the general public. They were taken over by the Royal Engineers Institute in the year 1876.

The Committee of the Institute have recently decided that the requirements of the present day necessitate some modification in the form and period of the above publications.

From the commencement of the current year the *Professional Papers* will be issued in separate pamphlets, and will be bound in volumes when and as often as sufficient Papers have been printed to fill a volume of convenient size. They will be practically confined to contributions of a highly technical nature and to others which are necessarily accompanied by numerous illustrations.

The *Royal Engineers Journal* will be published as a magazine available for purchase by the public, and will contain articles of interest to the Army at large as well as those of a technical character. Matter of a purely private or regimental nature will be printed in a separate *Supplement* in the same size, the present *Supplement* retaining its folio shape but changing its title to the *Royal Engineers Monthly List*. These last two will be strictly limited to private circulation.

This volume of the *Professional Papers* is the first of the new (fourth) series, and contains the Papers issued during the three years 1905, 1906, 1907.

A. T. MOORE,
Major, R.E.,
Secretary, R.E. Institute.

CHATHAM,
Autumn, 1907.

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PROFESSIONAL PAPERS.—FOURTH SERIES.

VOL. I.—No. 1.

SIMPLE TUNNEL WORK ON THE MARI-ATTOCK RAILWAY, PANJAB.

BY

CAPT. H. E. C. COWIE, D.S.O., R.E.

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SIMPLE TUNNEL WORK ON THE MARI-ATTOCK RAILWAY, PANJAB.

BETWEEN the Resi and Sohan rivers there is a summit 1,500 ft. above M.S.L. formed in four undulations, three of which were tunnelled through by the Mari-Attock Railway. Chab tunnel, the longest, has a brick lining 1,312 ft. long, of which 312 were cut and cover.

Plates I. and II. give a plan and a longitudinal section shewing the strata. The sandstone was soft, nothing stronger than country powder being required, except to start breakups, when dynamite was used. The gritty sandstone was the least treacherous; but large pieces, 3 ft. square with peculiar glazed surfaces, would continually flake off from the roof, necessitating at least four drawbars. General Description of Work.

The conglomerate at the south face had become moist and gave most trouble. This conglomerate when dry stands well, and has to be blasted. But on the south face bunds had been made (at AA, *Plate* I.) in 1893, when the bottom heading was taken out; and surface water collected here in 1894 to 1896 while the construction of this line was suspended, so that in June 1897 the portion between chains 3078 and 3084 was damp. This moisture was the cause of two slips of 25,000 cubic ft. each at chains 3081 and 3082, and created unnecessary difficulties at the south face of the tunnel; here pieces of 20 cubic ft. would fall away before the timbering was properly fixed up, and the hole continue to drip boulders for 2 or 3 hours before it was safe for the workmen to get in the complete timbering. 2 to 5 ft. thickness of roof would come away and be resting on the drawbars before the brickwork of the length had been built and backed. It is most important to drain away all water from the top of a tunnel. The 1893 bottom heading was 6 ft. × 7 ft., lined with sleeper frames 3 ft. apart and 2-inch poling boards.

The tunnel being on the straight, centre line and levels were given in 1897 by instrument once for all—(this could be done as the bottom heading, made in 1893, gave a clear line of sight for centre line marks and bench marks, which were put in at every 100 ft.)—, leaving the rest of the setting out to the *mistri*'s line and spirit level. Short checks by instrument were made from time to time; and the roof of the top heading checked every third day. Correctness of excavation facilitated work, especially where the roof was bad.

When work commenced in June 1897—(timbering AA, *Plate* III., was done on each outside face some time previously in April, while bricks and mortar were arriving)—, 18-ft. lengths of complete lining section were first built in open cutting near the tunnel faces at chains 3069.20 to 3069.40 and 3079.42 to 3079.60. At the same time a top heading, 6 ft. × 7 ft., was driven as in *Plate* III., and lined with sleeper frames (as in the bottom heading) wherever cracks or shakes appeared. Drawbars 1 and 2, *Plate* III., were then placed, and the full section continued, with drawbars 3, 4, 5 and 6 as considered necessary.

As soon as a length of brick lining had been built inside the hill, double timbering was started, so that brickwork and opening out should proceed simultaneously (see *Plate* IV.). This double length of timbering was quite simple under the conditions of rock met with. Referring to *Plate* III. it is clear that, the next length of brickwork reaching as far as Z, as soon as the full section had been excavated up to line RS, sill beam W and props YY could be got in and T taken out. The drawbars for portion PZ are then supported by the brick lining and the props YY. When the top heading is carried forward, drawbars for the portion ZO can be got in, resting on props YY and new short props M (*Plate* IV.). The situation then becomes like *Plate* IV., where the brickwork in A and the excavation in B can proceed simultaneously. In practice of course it is convenient to have top heading ready well in advance.

Such light timbering as here described could only be used in certain rocks. In Chab tunnel the clays and sandstones were as a rule quite dry, and would stand with vertical faces for a month or so; and no restrictions were imposed except by considerations of safety and reasonable precaution.

No mine was allowed within 4 ft. of the props without the permission of the tunnel inspector; and to further prevent blasts knocking the props off the sill-beams, iron footings for the props were made as in *Plate* IV.

While the outside face lengths were being built, a breakup was also started at 3072.30, and soon afterwards another at 3075.90. Breakups were started by driving a chamber straight up from the bottom heading, length 9 ft. and width that of the bottom heading, viz., 6 ft. When the chamber reached 25 ft. above formation a top heading was driven in each direction, and timber got in as in *Plate* V. The 9-ft. length was then opened out and the arch built. The timbering and opening out then proceeded in each direction as if from two faces.

In treacherous places the rule was to adopt single timbering as in

Plate III., and to reduce height of roof from 25 ft. to 24 ft., so that, if timber had to be left in, as little as possible might be lost.

The top of arch being 22 ft. 8 inch., 25 ft. total height of opening permitted the building of the arch with ease, and even if the drawbars sagged they would be clear of the brickwork.

Opening out and brickwork were done in 18-ft. lengths, this being reduced to 15 ft., 12 ft. or even 9 ft. where the rock was bad. 4 to 8 drawbars were used in each length. No mine was allowed within 4 ft. of the props or within 2 ft. of the opening-out section. The roof and sides were cut smooth with picks, which facilitated and saved timbering and detected any dangerous pockets which, if neglected, led to accidents. Opening Out.

Opening out was done by local Pathans, miners from Dandote or from the Khewra salt mines. Separate gangs of Panjabis mucked out. An 18-ft. length, with 2 shifts of 20 miners each and 2 shifts of mucking-out gangs of 16 men each, could be completed in 10 to 15 days.

The lining was 5 bricks thick, increased to 6 in the arch in bad ground. Dimensions are given in *Plate* VI. An 18-ft. length was completed up to 14 ft. above formation in 5 days (3 days when in a hurry) by 6 masons fully supplied with materials; $1\frac{1}{2}$ days were required to move, adjust and clean the centring; and the arch was finished in another 5 days. The brickwork templates are shewn on *Plate* VI., and the centring on *Plate* VII. Brickwork.

18 ft. of centring was more convenient if made in 2 lengths of 9 ft. Centrings had to be adjusted and trimmed after each refix, as the wood swelled. Care in first fitting a centring exactly to dimensions in the workshop outside the tunnel was always well repaid. For this purpose a full-sized diagram was made on a concrete platform outside, from which all templates, etc., were made and checked.

Bricks used were 10 inch. $\times$ $4\frac{3}{4}$ inch. $\times$ 5 inch.; 24 cubic ft. of wet mortar (20 soorki, 13 lime) was allowed per 100 cubic ft. of brickwork; this mortar was ground by steam for $1\frac{1}{4}$ hours.

There were 5 keys in the lining horseshoe. In order to find the correct number of bricks between any two keys, dry bricks were laid touching on the full-sized diagram, and $\frac{1}{16}$ inch to $\frac{1}{18}$ inch per brick allowed for joints. This allowance seems small compared with the usual $\frac{1}{4}$ inch; but in practice was found workable and sufficient to give a fair bearing, though objectionable from the point of view of the contractor, who considered his brickwork the finest between Peshawar and Tuticorin.

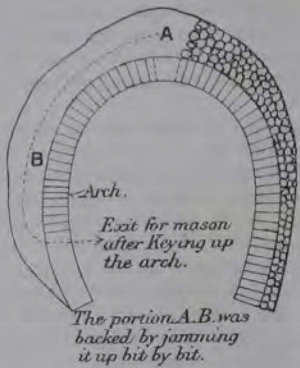
Uniformity of pressure in the 5 courses was sought, rather than very fine work on the inside or visible face.

1,600 bricks* were used per 100 cubic ft. of brickwork as

* Breakage from previous handling was very great; after chipping, etc., 1,256 bricks were actually in the finished work.

measured for payment to the contractor. Bricks and soorki were found departmentally. Lime was supplied unslaked at site by contract.

When two working faces met, the junction was always effected by a manhole at one side, which is much better than keying in from underneath. The only difficulty in these junctions was to get sufficient

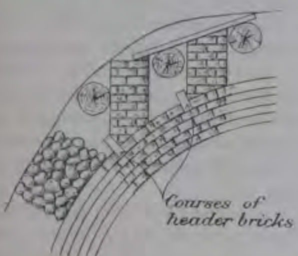


light and ventilation for the masons and backing squads; for a complete chamber is formed, with the centring as the floor and the two meeting working faces of completed tunnel as the end walls. Want of ventilation does not often affect the native of India, and a small hand fan was all that he required; but as few oil lamps as possible were used, light being reflected up between the laggins by means of mirrors. The key bricks were laid in the ordinary way until the last two feet only remained. For this length of keying all the bricks were first carefully fitted without mortar, then taken out and built in quickly with mortar. The backing, as shewn in the sketch, was left uncompleted on one side for a length of 4 to 6 ft. and gradually filled in from the top of the arch downwards by a process of jamming and wedging and putting in boards between the arch and the rock.

It will naturally be asked whether the drawbars in these junction lengths were saved. In Chab tunnel they were saved in one out of the three junctions—by choosing for the junction a place where the roof was sound, and by then taking out the drawbars just before the centring was brought under the gap and building in the arch and backing as quickly as possible. In most junctions the drawbars would have to be left in. It is to be remembered that at Chab wood of all sorts was scarce, especially drawbars of sal (*shorea robusta*).

Backing was of round stone, found locally on the hill slopes. Where the roof allowed, backing was carried up to drawbars 3 and 4, which were then taken out; and to 1 and 2 in the same way. Any cracked or flaked pieces in the roof were strutted up from the arch. Backing.

Where the roof was bad this could not be done, and the backing was in such places put in more slowly piece by piece, or built up between the drawbars, which were then taken out. In the worst places brick in mud or in lime was used, if the height between arch and roof was over 2 ft. In order to keep the backing from sliding down the arch, headed bricks were left projecting at the necessary places.



Altogether 10 drawbars were lost, it being impossible to extract them, and very few poling boards; the latter could nearly always be saved, if placed originally with the idea they were to be taken out.

To take out 8 props, refix the sill-beam and 8 props (opening out for the drawbars going on meanwhile) required 4 days. All timbering was carried out departmentally by an African tunnel inspector, head mate, 4 *khalassies* and 25 men, all natives. When 6 faces were in full swing these men had their work cut out, as they also had to line the top heading and renew the lining of the bottom heading which had rotted. Timbering.

The little ventilation required can be seen from *Plate* I. The pipes were 10 inch. diameter, of $\frac{1}{16}$-inch iron with flanged ends. The fans, made with vanes like a turbine, sucked the foul air out. Ventilation.

Each fan was worked by 4 men; the men who worked them, inhaling the foul air as it came out, were the first to get fever, and never lasted more than 2 months. An arrangement was afterwards made to lead this foul air above the men's heads. The effect of these fans was good. After blasting with country powder in a breakup work could start in 15 minutes. Masons on the top of the centring suffered considerably if the fans stopped.

Drainage.

There was no water in the tunnel, but rain water coming down the south face cutting had to be passed through. The main air pipe was used as a drain. During rain very little work went on, so that the ends of the pipe could be opened.

Lighting.

Miners and masons used the ordinary open lamp, burning kerosene oil. Such a lamp can be hooked on nearly everywhere. Mirrors reflecting in the sunlight were used at both outside faces, and were very efficient.

Accidents.

(i.). Two men were killed when relining the bottom heading, about 500 cubic ft. coming down.

(ii.). One man was killed by a lump of 3 cubic ft. falling from the roof. This occurred from neglect of the order to trim the excavation with pickaxes, an operation that detects loose pieces.

(iii.). A powder explosion occurred in No. 1 breakup from a Pathan lighting his pipe over the powder canister. Both pipe and canister were strictly forbidden inside the tunnel. A stampede ensued among the masons, who in the dark attempted to jump down from the centring. Two were killed and two injured. The guilty Pathan came out scorched and smiling.

(iv.). One man was killed by a prop falling after a blast. Only 4 or 5 props were knocked down by the blasting in the whole course of the work; and in every case the rule of no mine within 4 ft. had been transgressed.

Progress.

The progress averaged one length of 18 ft. on a working face per month. There were 2 slips in the south face cutting, which delayed the south face and No. 2 breakup for $2\frac{1}{2}$ months. Towards the end 2 lengths per month were often put in on one face.

Work began in June 1897, and the 1,000 ft. of tunnel with 312 ft. cut and cover were finished in July 1898. Excluding wet days, holidays, and closed days when the slips occurred, the rate was 4 ft. per diem.

Progress was considerably delayed from the scarcity of water, which had to be brought in May and June 1898 from a distance of $2\frac{1}{2}$ miles in 4 ft. × 4 ft. × 4 ft. tanks running on trollies. A 2-inch pipe, connected with the elevated tanks outside the tunnel, would have been convenient. Water carriers and water trollies could then have emptied into these elevated tanks instead of crowding the small available approaches to the working faces.

General.

Tunnelling is essentially work that can be carried out departmentally, as the officer in charge, who has to measure and pay for the work, can make sufficient measurements by observing the lineal progress and can make payments on completion of a length in which the quantities are a standard type.

The opening out of an 18-ft. length could be given to a gang with inducements to work quickly, the mucking out to another gang, brickwork to a batch of masons, and backing done by petty contract.

After September 1897 work was carried on day and night. Opening out went on at night with 2 *khalassies* to watch the timbering. Backing and brickwork were not allowed at night except by order of the sub-divisional officer.

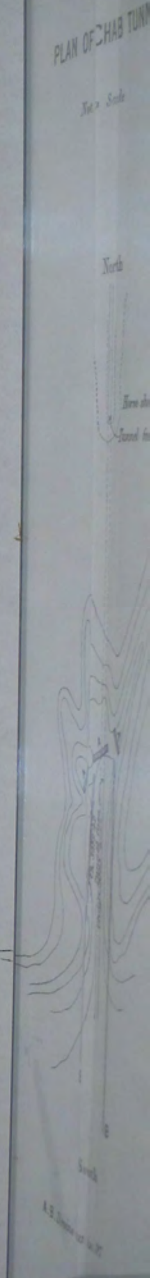
All mucking out and carriage of materials for brickwork and backing were done on the 2-ft. line running through the bottom heading. The track was doubled outside the tunnel, and loops put in at each breakup as soon as there was space enough.

Actual Cost of Chab Tunnel, 1,312 Feet.

Quantity.	Description.	Rate Paid to Contractor.	Unit.	Rate.	Amount.	Cash.	Stores.
Cubic ft.		Rs.	Cubic ft	Rs.	Rs.	Rs.	Rs.
7,000	Open excavation ...	25	°/₀₀	28·57	200	200	—
42,000	Heading	—	°/₀	57·62	24,200	20,000	4,200
648,000	Opening out	100	°/₀₀	127·16	82,400	70,000	12,400
	Timbering		lump	sum	8,600	3,000	5,600
1,63,000	Arching in bricks ...	*22	°/₀	74·23	121,000	100,000	21,000
1,34,000	{ Concrete	20	°/₀	20·15	27,000	27,000	—
	{ Backing	15	°/₀	—	—	—	—
	Main slabs	—	lump	sum	900	900	—
	Tools depreciation ...	—	—	—	7,000	—	7,000
	Contingencies	—	—	—	9,000	7,000	2,000
	Total	—	—	—	280,300	228, 00	52,200

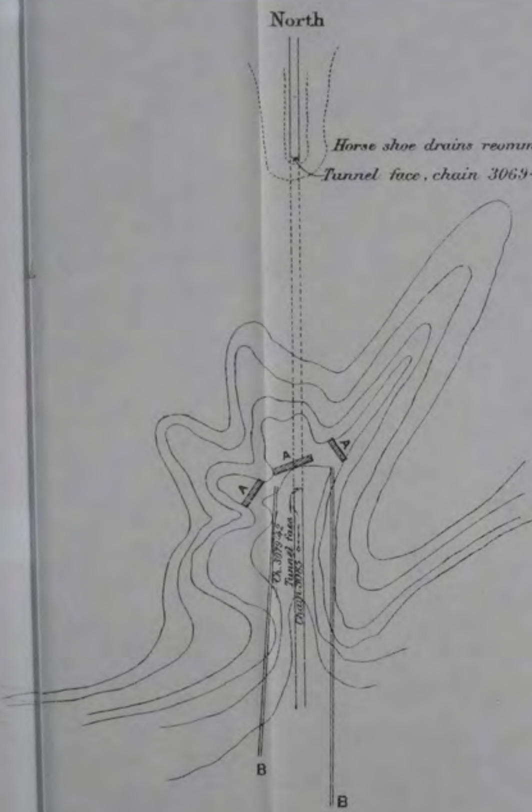
Cost per ft. run .. .. Rupees 213.

* Bricks and soorki supplied by department.


North
South

PLAN OF CHAB TUNNEL. PLATE I.

Not to Scale



A. B. *Drains cut in 97*

PROFESSIONAL PAPERS.—FOURTH SERIES.

VOL. I.—No. 2.

LONG SPAN BRIDGES.

BY

M. AM ENDE, M. Inst. C.E.

(Lecture delivered at the School of Military Engineering on 15th December, 1904).

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LONG SPAN BRIDGES.

IN a discourse on Long Span Bridges it appears to me unnecessary to describe those properties which they have in common with Short Span Bridges, such as :—the design and manufacture of the parts, the quality of the material of which they are made, and the nature of the foundations.

Considering also the shortness of time, reference to Methods of Erection and to the subject of Stresses and Factors of Safety may be incidental and brief.

But there is one feature about Long Span Bridges which distinguishes them materially from those of ordinary dimensions and to which I propose to direct your attention, and that is the great quantity of metal required in their construction.

It is generally known that the weight of a single span of 1,500 ft. would be a great deal more than that of six spans of 250 ft. each, and that the rate of increase grows with the span. What is the law of increase ?

Does the increase go on without limit and is the length of span only a question of spending enough money to realise it ? or is there a measurable limit of span where the quantity of metal would be infinite ?

An answer to the latter question may be of no importance to practical engineering, but the knowledge of the Law of Increase is of much practical use, and it would necessarily include the answer with regard to the limit. The weight of the structure is the very first item required in the design of a bridge, and in the calculation of its cost, formulæ for the weight, as the result of compilation from facts, have always been highly appreciated by engineers.

Any Law of Increase can be expressed by a curve, and short pieces of any curve can be compared to a straight line.

Hence it comes that the formula

$$\text{Weight per foot lineal} = a + b\text{L},$$

where L is the span and a and b are constants, gives good results for bridges of a given class and type for a moderate range of spans.

There are four classes of bridges : Suspension, Arch, Cantilever, and Simple Girder, each class with innumerable types according to the form and dimensions of the parts and according to the loads to be carried.

If, then, we require a formula showing the Law of Increase for one of the four classes, covering all types and the whole range of spans, it must contain symbols for the loads and for the dimensions of the parts, as also coefficients indicating their construction, corresponding to a and b in the formula just quoted. To avoid great length, and bearing in mind that such formula can at best only be used to obtain an approximate estimate of weight and to facilitate the first steps in the design and the calculation of the stresses of a bridge, we should regard groups of parts, such as those constituting the web of a lattice girder, or the parts of the platform, as a whole and assume them to be constructed in the most usual manner.

Suspension Bridges.

Fig. 1, *Plate* I., is a diagram of a suspension bridge with stiffening girder, of which class four types are shown in *Plates* II. and III. The main dimensions are :—

L, the span, in feet.
H, the depth of the catenary chord, in feet.
B, the width of the platform, in feet.
D, the depth of the stiffening girder, in feet.

Let

p be the weight of the platform, per foot lineal in tons.
m the moving load, ,, ,, ,,
w the wind pressure, ,, ,, ,,
g the weight of the main structure, ,, ,, ,,
t the total weight, ,, ,, ,,

The following assumption will here be made :—

$H=\frac{L}{8}$; provisionally.

$B=\frac{L}{30}$; in very large bridges only a portion of this width may have to be covered with the road material.

$D=\frac{L}{40}$; being a usual proportion.

p; consisting of the weights of the cross girders, stringers, and road material, all increasing gradually with the span. (See *Fig.* 2, *Plate* I.).

m; decreasing with the span according to rules generally laid down in each case. (See *Fig.* 2, *Plate* I.).

$w=\frac{1}{60}\left(20+\frac{L}{80}\right)$; an empirical quantity dependent on the assumed wind pressure per square foot and on the surface exposed to it by the structure.

The main structure consists of four main parts, and the weight per lineal foot will be named as follows :—

α=weight per lineal foot of catenary chord, in tons.
β= ,, ,, ,, suspenders, ,,
γ= ,, ,, ,, stiffening girder, ,,
δ= ,, ,, ,, wind bracing, ,,

Let, further,

$$s_1=20\ ;\ s_2=4\ ;\ s_3=5\ ;\ s_4=8 \text{ tons}$$

be the permissible stresses per square inch of steel in the four above-mentioned parts respectively, and

$$c_1=1{\cdot}08\ ;\ c_2=2\ ;\ c_3=1{\cdot}4\ ;\ c_4=6 \text{ to } 8\ ;\ c_5=1{\cdot}4 \text{ and } c_6=6 \text{ to } 8$$

be six coefficients of construction, to be used hereafter in the formulæ for the actual weight of the four parts and indicating the differences between their actual and their theoretical volume. These coefficients are determined by the analysis of structures carried out or designed in detail, and the collection of results of such analysis would be a very useful although laborious work. For the present purpose, which is only to illustrate the law of increase of the weight with the span, the coefficients have here been stated according to personal experience, reserving any necessary correction for the future.

The theoretical volumes of the four parts will be as follows:—

Catenary Chord ...... $\frac{1}{s_1}\left(\frac{L^3}{8H}+\frac{2}{3}HL\right)t.$

Suspenders .... $\frac{1}{s_2}\frac{HL}{3}\left(p+m+\gamma+\delta\right).$

Stiffening Girder...... $\frac{1}{s_3}\left(\frac{L^3}{32D}+\frac{L^2}{24}\right)m.$

Wind bracing .... $\frac{1}{s_4}\left(\frac{L^3}{6B}+\frac{L^2}{4}\right)w.$

To show what is understood by the term "theoretical volume," I take the example of a simple plate girder carrying the uniformly distributed load, p, per lineal foot. The theoretical volume, as will be seen from *Fig.* 3, *Plate* I., is

$$p\left(\frac{L^3}{6Ds}+\frac{L^2}{4s_1}\right) \text{ feet} \times \text{inches}^2$$

if s is given in tons per square inch, p in tons, and L and D in feet. If a plate girder could be made with flanges diminishing according to the parabola, and with a web diminishing in thickness to nothing in the middle and without joints, the actual volume would be equal to the theoretical volume. As this cannot be, the coefficients c must be introduced, and thus we have the actual volume. This formula follows from the theory of stresses, and so do the formulæ, stated above, for the theoretical volume of the four parts of the main structure of the suspension bridge.

In those formulæ it has been assumed that the weight is evenly distributed. This is approximately the case in most suspension bridges, as the increase of weight of the catenary chord towards the towers is compensated by the increase of weight of the wind-resisting structure towards the middle. An even distribution may also be assumed in most cases of arch and girder bridges. It is, however, inadmissible in the case of most long span cantilever bridges, as in these the possibility of lightening the parts near the middle in comparison to those near the supports is found to be a source of great economy. But in the present case it is admissible to divide the above values by L, and thus to obtain theoretical volumes per lineal foot. Multiplying further by the weight of a steel bar, one foot long and a square inch in section, $\frac{1}{660}$ ton, we have theoretical weights; and finally, multiplying by the coefficients c, we have the actual weights of the four parts per lineal foot as follows:—

Catenary Chord ... $\alpha = \frac{c_1}{660 s_1}\left(\frac{L^2}{8H} + \frac{2}{3}H\right) t$ ....(1).

Suspenders .... $\beta = \frac{c_2}{660 s_2}\frac{H}{3}\left(p + m + \gamma + \delta\right)$..................(2).

Stiffening Girder... $\gamma = \frac{1}{660 s_3}\left(\frac{L^2}{32D}c_3 + \frac{L}{24}c_4\right) m$ ....(3).

Wind bracing ...... $\delta = \frac{1}{660 s_4}\left(\frac{L^2}{6B}c_5 + \frac{L}{4}c_6\right) w$ ....(4).

We have $g = \alpha + \beta + \gamma + \delta$ ....(5).

and $t = g + p + m = \alpha + \beta + \gamma + \delta + p + m$...............(6).

Putting this value for t into (1) we find

$$\alpha = \frac{c_1\left(\frac{L^2}{8H} + \frac{2}{3}H\right)(\beta + \gamma + \delta + p + m)}{660 s_1 - c_1\left(\frac{L^2}{8H} + \frac{2}{3}H\right)} \quad \text{................(7).}$$

All necessary numerical values have been given above, and the actual weight of the four parts can now be calculated for various spans; they have been plotted in *Fig.* 4, *Plate* I.

It will be noticed that γ and δ can be calculated direct from (3) and (4) and that β is then also determined. The unknown quantity l in (1) has been eliminated in (7). Here we can see that α determines the limit of span; it lies where the denominator of the fraction becomes *nil*, α being then infinite, *i.e.* at L=11,282 ft.

It may be remarked that some function of β should be added to p, m, γ, and δ in the parenthesis of (2), and that this would give an expression for β similar in form to (7), limiting the depth of the catenary chord, H; but such depth would be quite beyond those coming into consideration within the limit of L, and the effect of the addition has been ignored as immaterial. But it shows that parts which carry their own weight, as the catenary chord and the suspenders, determine limiting dimensions; while parts which do not, as the stiffening girder and the wind bracing, would simply go on increasing but would not become infinite as long as L is finite.

Now let us suppose that a cable suspension bridge of 3,000 ft. span has to be designed, carrying four lines of railway. The span is unprecedented; and the questions arise whether the permissible stresses s, determined conventionally on the basis of existing practice, could not be revised, or whether an alteration in the proportions of H, B, and D to L would not be profitable.

According to *Fig.* 5, *Plate* I., which shows an enlargement of some of the ordinates in *Fig.* 4, the weights per lineal foot of the four parts are:—

Cable	5·57 tons
Suspenders	1·35 ,,
Stiffening girder	5·15 ,,
Wind bracing	4·90 ,,
	16·97 tons.

First in respect of the cable: Ropes made of the best steel will resist a strain of 120 tons per square inch. Assuming a factor of safety of 4 to be sufficient, we should have $s=30$. The height of the towers, with $\frac{H}{L}=\frac{1}{8}$, as assumed, would be 375 ft. *Fig.* 6, *Plate* I., is a diagram showing the weight of the cable for L=3,000 ft. and for various proportions of $\frac{H}{L}$. At $\frac{H}{L}=\frac{1}{30}$ it is infinite, and at $\frac{H}{L}=0·435$ it is a minimum; but it can be seen that beyond a proportion of $\frac{H}{L}=\frac{1}{4}$ very little can be gained and, considering the cost of very high towers, a proportion of $\frac{H}{L}=\frac{1}{6}$ would probably be the utmost.

The next item to be examined is the weight of the stiffening girder, dependent only on the moving load or, more accurately, on the degree of inequality of its distribution. In the formula the greatest possible inequality has been assumed; but on a bridge for four lines of rails this could hardly ever occur, or, if it does occur at rare intervals, it is not necessary that the factor of safety should be so low as assumed. Therefore, either m may be reduced or s_3 may be increased. We assume $s_3=7$.

Finally, in respect of the wind bracing it would be advisable to increase B to $\frac{L}{25}$ by splitting the platform in two and having an open space of about 60 ft. between the two halves, occupied only by cross girders and diagonal braces. s_4 may also be somewhat increased, as the average wind pressure on a large surface never reaches the amount assumed for smaller structures.

The new assumptions are now as follows:—

$$\frac{L}{H}=6, \frac{L}{B}=25, s_1=30, s_3=7, s_4=9,$$

and the weights, re-calculated from formulæ (1) to (4), will be:—cable 2·12; suspenders 1·45; stiffening girder 3·68; wind bracing 3·8 tons: total 11·05 tons. On the same assumptions the limiting span would be 21,300 ft.

With the results, thus obtained, the towers and anchorages can now be designed and their weight and cost, as also the cost of the whole bridge, approximately calculated. Then the parts (beginning again at the stiffening girder and the wind bracing) would be designed in detail and their weight ascertained from such details. The results, if they agreed with those already found, would be a proof that the coefficients c are correct; or, if not, would be a means to correct them.

The above example shows strikingly the effect of any change in those more or less arbitrary and conventional assumptions for m, w, and the various stresses s which must be laid down in every prospectus of a new work; and therefore also shows how useful would be a formula, such as stated here, to those who draft the prospectus as also to the designer of the structure.

I will now make some observations on the diagrams of long span bridges shown on *Plates* II. to VII.

The first Plate shows the Williamsburg Bridge over the East River, New York, finished in the present year. It is a wire cable bridge with a stiffening girder of the ordinary type, namely continuous over the centre. A hinged girder, such as I have assumed in *Fig.* 1, *Plate* I., has the advantage that the stresses in it are independent of the deflection of the cable, but the disadvantage that the cable when it deflects would be subject to bending stresses near the hinge. After deflection the line of the platform would be slightly broken at the hinge; and as the cable must follow that line, the sharper curvature might be the cause of bending stresses which are not negligible if the cable has a large diameter and if its length outside the towers is very great.

The second diagram shows the Manhattan Bridge, also over the East River at New York, and now in course of construction. It has its stiffening girder attached to the catenary, so that the latter is used as one of the chords of the girder. Some economy of metal is claimed for this arrangement; but while in the Williamsburg Bridge no transverse bracing is required between the cables—the surface exposed to wind pressure being very small—, it is doubtful to me whether such bracing may be omitted in the Manhattan Bridge. There are four catenaries in vertical planes 28 ft., 40 ft., and 28 ft. apart, and probably there will be bracing in the 28 ft. spaces between the catenaries; but the existence of these bracings will not appreciably reduce the stresses in the main wind bracing which lies in the platform and which has an effective width of 96 ft. The catenaries will be made of eyebar links, so that the parts of the stiffening girder which transmit stresses to them may be effectually fixed to it, while such fixing to a cable would be impracticable.

The material of the eyebar links will be nickel steel of an ultimate strength of 38 tons per square inch, and will be strained to 13 tons under the greatest load. I wish to call attention to the fact that this is double the strain allowed by the Board of Trade in this country for ordinary steel and for short span bridges. The work will be watched with great interest in respect of the official tests with the new material, nickel steel, and in respect of the new construction of the stiffening girder, especially by those engineers whose views are represented in the Williamsburg Bridge. The case of a railway suspension bridge with a stiffening girder attached to the chain is not quite new; it is about 30 years ago, that such a bridge was taken down in Vienna on account of excessive oscillations under a passing train; but a comparison of the two cases may be irrelevant on account of the vastly greater dimensions of the Manhattan Bridge.

The third bridge in magnitude, but of an earlier date than both the above, is the Elizabeth Bridge over the Danube at Buda Pesth (*Plate* III.). The stiffening girder is continuous, not only in the middle but also at the towers, resting there and on the abutments on pendulums. The stresses in the girder have to be calculated with three unknown quantities, which can only be determined by assuming conditions in the erection not easily controllable. Rolling saddles under the catenary on the top of the towers—a common feature in older suspension bridges—have here been abandoned, and pivots have been introduced instead at the bottom of the towers. This construction will also be adopted in the Manhattan Bridge.

Originally the Elizabeth Bridge was designed as a cable bridge, with a cable terminating in socket connections at the towers, and with eyebar links on the other side of the towers.

The probable reason why this was abandoned was the difficulty of making a cable conforming to the considerable differences of stress on the two sides of the towers (about 15 per cent.). These novel conditions led to the abandonment of the cable in favour of chains made of eyebar links. A new difficulty arose in the fact that Iron works in Europe did not possess the costly plant for making eyebars of the required length without weld; and it was finally decided to cut them out of simple flat bars with machines constructed for this purpose, but less costly than an American plant for making weldless eyebars.

Similar circumstances attended the conversion of the cable of the Albert Bridge over the Thames at Chelsea into a chain in 1887, and compelled the contractors for the work, Messrs. Handyside & Co., of Derby, to employ the same expedient. It appears from these facts that the eyebar has not yet fallen into disuse as might have been supposed sometime ago when American engineers returned more generally to the European practice of making riveted connections.

The Niagara Suspension bridge (*Plate* III.) was erected in 1898 in place of the one built in 1850. It differs from the old structure mainly in respect of the stiffening girder, which was of wood and is now of iron.

ARCH BRIDGES.

There is only one Arch-bridge exceeding in respect of span the largest simple girder-bridge in existence, viz., 550 ft. It is the Niagara Bridge at Clifton (*Plate* IV.), with a span of 840 ft., built in 1898. Previously to this date arch-bridges of larger span than this had been proposed on several occasions, when they would have been more economical than bridges on other systems—namely either when the adjoining spans could be treated as short span viaducts, or when there was no room for adjoining spans at all.

The principal objection to the arch seems to have been the view that for its erection without scaffolding it has to be temporarily converted into a cantilever, and that the construction of a permanent cantilever bridge would be more economical or at least more convenient. As, however, the temporary parts would only carry the weight of the arch without platform and moving load, and as it would mainly consist of wire ropes of a strength three times that of the permanent parts of the cantilever, the objection to arch-bridges on this account seems to be unfounded.

The next bridge, more remarkable for its situation than for its size, is the Zambesi Bridge close to the Victoria Falls in South Africa. It has been designed by Sir Douglas Fox and is now being erected by the Cleveland Bridge Company, Darlington, to whom I am indebted for the detail drawing on *Plate* V.

The third arch-bridge here illustrated crosses the Baltic and North Sea Ship Canal with a span of 537 ft.; and the fourth is the Washington Bridge over the Harlem River, New York. All these arches have hinges at the abutments but none in the middle.

In regard to the stresses from the load, there is a strong resemblance between arch and suspension bridges, because the bracing between the two chords of the arch (as in the Clifton bridge) or between chord and horizontal member (as in the Zambesi bridge) is only affected by the moving load, and the stresses can be determined either by the usual theory of arches or by the theory of a catenary with stiffening girder. A similar formula to that for suspension bridges may therefore be used also for arch bridges, if the arch is flat and if regard is had to a difference in the nature of the wind bracing. This latter generally lies between the arches, and as it terminates in two fixed points at each abutment and cannot turn there as in a suspension bridge, it resembles a continuous girder and is heavier at the abutments than in the middle. The theory of stresses in such a wind bracing can no longer be regarded as a very difficult problem, and a discussion of it may be found in a Paper which I published in *The Engineer* in April, 1893.

If the arch is deep, the centre of gravity of the half span would be moved perceptibly away from the middle, and this would alter the constant 8 in the expression for the theoretical volume of the catenary chord. In long span arch bridges it would be imperative to avail oneself of the economical advantages of a large proportion $\frac{H'}{L}$; and as no towers have to be built, a proportion of 1 in 4 (*Fig.* 5, *Plate* I.) may well be contemplated. Moreover, the arches of long span bridges are sometimes built in two planes inclined towards each other, as is being done in the Zambesi Bridge, and this would be another cause of a movement of the centre of gravity away from the middle. In such cases it would not be difficult to mark approximately the position of the centre of gravity of each part $\alpha, \beta, \gamma, \delta$, and to find the centre of gravity of the whole with the results of the first calculation. This would give the correction of the constant 8 into (say) $7\frac{1}{2}$ or 7, and the calculation would then be made a second time.

Cantilever Bridges.

The system of Cantilever bridges originates from localities where a complete scaffolding for the erection has been impracticable, namely deep ravines, mountain torrents, or rivers with uninterrupted navigation; and it is therefore at least as old as the system of suspension bridges, which are erected by hauling or throwing a rope across a chasm as a first step in the operation. Arches and simple girders, if erected without scaffolding, must be temporarily converted into cantilevers, and the Zambesi arch shows clearly how an arch may be constructed so as to do this with the least quantity of material for temporary work. Continuous girders, when erected by launching them across from pier to pier, become cantilevers temporarily; and girders continuous over three spans—if at the points of change of flexure in the middle span the chords are cut—are cantilever structures in the present sense of the term, consisting of two cantilevers and a central girder.

In a very valuable description of the Forth Bridge, published in February, 1890, as a special number of *Engineering*, an interesting discussion is given of the historical development of the modern cantilever bridge. Besides some ancient examples of actual structures arising from the necessity of an erection without scaffolding, a number of proposals or designs, previous to the conception of the Forth Bridge, are brought forward, which testify to its development from the continuous girder.

The modern cantilever bridge, of which three examples are shown on *Plates* VI. and VII., may also have originated from the system of an arch and a catenary intersecting each other in two points and braced together as shown in *Fig.* 1, *Plate* VII. This system was first proposed by Rupert for a bridge over the Bosphorus (see *The Engineer*, September, 1867). At the points of intersection of arch and catenary in the main span both are cut, and an expansion joint is introduced at one point or at both. The main span then consists of two cantilevers and a central girder. Making the two points approach each other, as in *Fig.* 2 (*a*), *Plate* VII., the proportions of the three parts longitudinally would be the same as in the Forth Bridge; but as their vertical dimensions near the middle would be impracticable, they appear increased in the Forth Bridge, as shown in *Fig.* 2 (*b*). Making the two points recede to the piers the cantilevers disappear and we have a simple girder of the type of the Saltash Bridge near Plymouth, with a span of 456 ft., built in 1855.

The Blackwell Island Bridge, New York (*Plate* VI.), now in course of construction, is a cantilever bridge without central girders in the main spans. It consists of five spans, of which the second and fourth are main spans, while the first, third, and fifth are anchorage spans. This arrangement may be regarded as a repetition of that of the Forth Bridge, consisting of seven spans, if we ignore its second and sixth as ineffective anchorage spans and as being introduced mainly on account of the scheme of erection. The top member and the diagonal ties of the Blackwell Island Bridge will be made of eye-bars; and, so far as can be seen from the drawings at present available, the two main spans, one of which is 1,182 ft. long, will have expansion joints in the middle, and one of the towers adjoining the central anchorage span will be moveable on a roller bearing.

The calculation of the weight of a cantilever bridge, on the lines previously indicated for a suspension bridge, is impracticable on account of the greatly varying proportion of length of the central girder to the span in existing bridges; but if the most economical proportion could be found, at least approximately, the principal difficulty would be overcome. The weight of the central portion could be easily ascertained from existing examples of simple girder bridges, and it would then be comparatively easy to find the most economical form and the weight of the cantilever, seeing that, beginning at its nose, each of its panels could be designed by itself without having regard to the panels behind it.

An investigation into the best position of the two cuts or hinges, determining the length of the central girder, would, however, be based more suitably on the continuous girder with parallel chords than on the system *Fig.* 1, *Plate* VII., as the origin of the cantilever bridge.

In *Fig.* 7, *Plate* I., the surface enclosed by the parabola and the horizontal line TT′ represents the theoretical volume of the chords of a girder with parallel chords, assuming the load to be uniformly distributed. If the distance of the two hinges from the middle is $x=\frac{l}{2}$, it can be shown that the volume of the chords is a minimum, as also the volume of the whole span, because the web remains the same. If $x=l$ the volume of the chords is $2\frac{2}{3}$ times as great, and if $x=o$ it is $1\frac{1}{3}$ times as great. The ordinates of the curve AA (*Fig.* 8, *Plate* I.) show these volumes. If now the shape of the cantilever portion is altered, the parabola as a curve of moments remains, but as a curve of volume it gives way to that shown in *Fig.* 7 (*b*), and the corresponding curve in *Fig.* 8 will be the curve BB. The volumes of the curves are greatly reduced and the minimum lies near the middle. The volumes of the web differ for various positions x, but the difference is immaterial.

In cases where the weight of the structure forms an important part of the total load, the latter can no longer be considered as uniformly distributed; and as the centre of gravity of the volume of the chords moves towards T and T′, the curves of volumes AA and BB (*Fig.* 8) will be modified. The curves A′A′ and B′B′ give the distances of the centre of gravity from T and T′, and they must be compared to the corresponding curves AA and BB in order to arrive at the most favourable distance x of the hinges from the centre. Other alterations of the shape of the cantilever have been tried with the result that the position of the four curves (*Fig.* 8) varies, but that their main feature remains the same, viz., that the position of their minimum ordinates is between $\frac{x}{l}=0$ and $\frac{x}{l}=\frac{1}{2}$ but never reaches $\frac{x}{l}=0$. We then come to the following conclusions:—

1. For a cantilever structure with parallel chords (*Fig.* 7, *a*) the most favourable position of the hinges will be $\frac{x}{l}=$ from $\frac{1}{3}$ to $\frac{1}{4}$.

2. For a cantilever structure of increasing height towards the towers T and T′ (*Fig.* 7, *b*) the most favourable position of the hinges will be $\frac{x}{l}=$ from $\frac{1}{4}$ to $\frac{1}{5}$.

3. A further reduction of $\frac{x}{l}$ to *nil* impairs the economy of material but slightly.

Coming to real structures we find in the Forth Bridge the length of the central girder one-fifth of the span, $\frac{x}{l}=\frac{1}{5}$; in the Sukkur Bridge one-quarter of the span, $\frac{x}{l}=\frac{1}{4}$; and in the Blackwell Island Bridge no central girder, $\frac{x}{l}=0$.

The latter structure has the disadvantage that the deflection of one cantilever would affect the stresses in the other.

In the Forth Bridge (*Plate* VI.) as well as in the Sukkur Bridge (*Plate* VII.) the top chords of the cantilevers are parallel to each other in plan and at the same distance apart as those of the central girders; but while the planes of the webs of the latter are vertical those of the cantilevers are inclined towards each other. In this way the bottom chords, being also part of the wind-resisting structure, are spread out to greater distance apart towards the towers, and the economical shape and the proportion $\frac{x}{l}$ of the upright structure is here repeated in plan. The whole wind pressure is conducted down to this structure by vertical frames, and these have also the economical shape of being narrow at the top and wide at the bottom.

Considering these points, and the fact that the Forth Bridge is not only the largest but also the first of its kind, we must acknowledge that the correctness of its main proportions is very remarkable.

PLATE I.

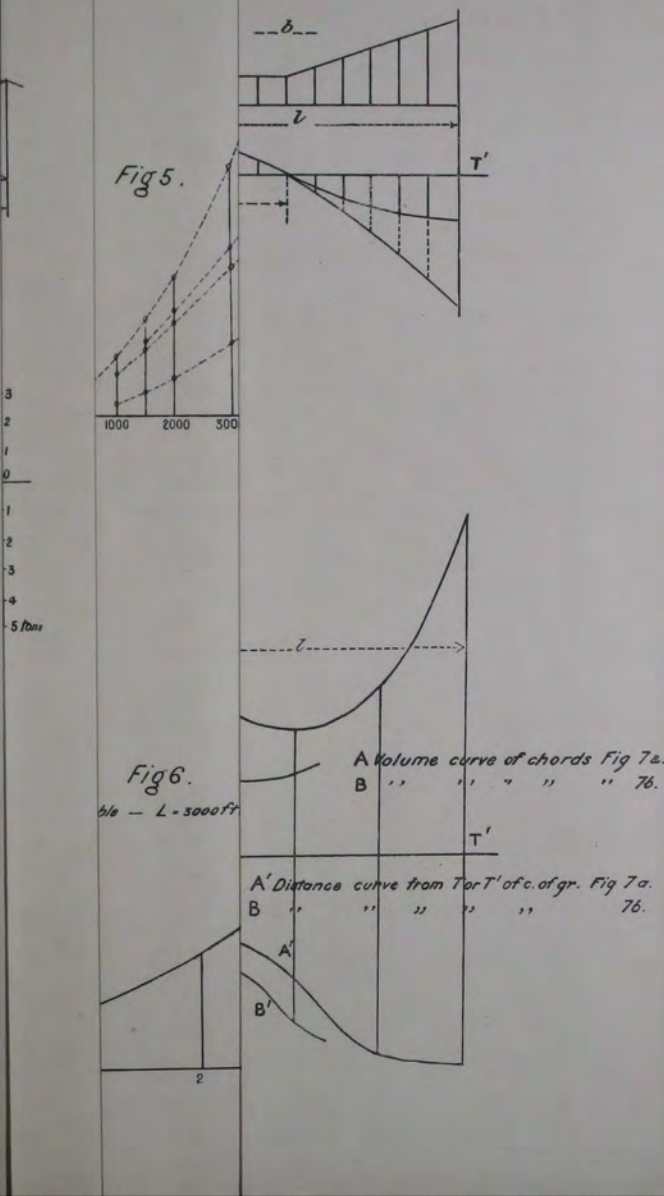
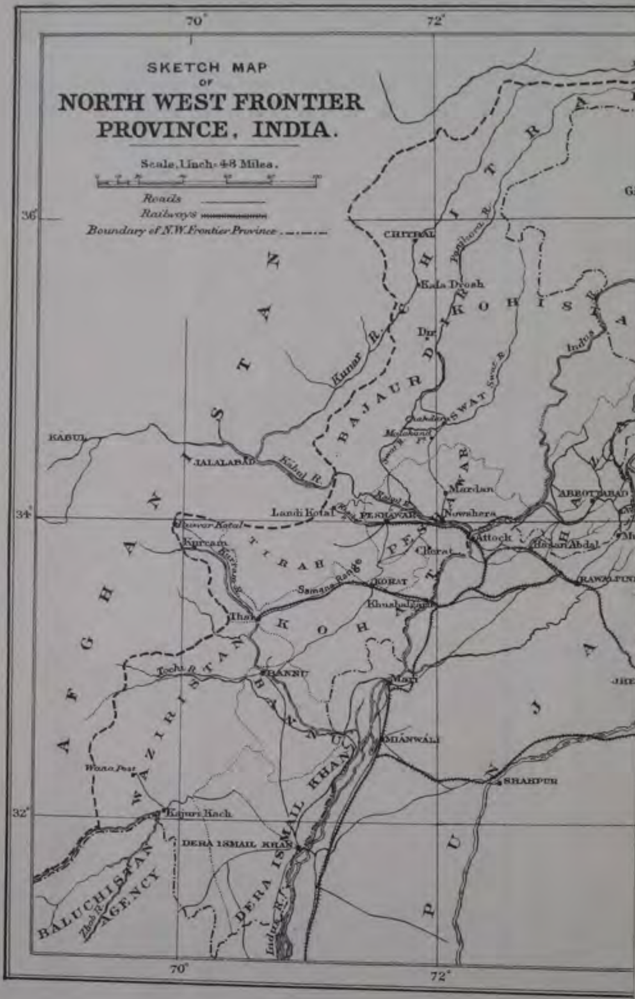


Fig 5.
b
l
T'
1000
2000
300
3
2
1
0
1
2
3
4
5 tons
l
Fig 6.
ble — L - 3000 ft
A Volume curve of chords Fig 7a.
B " " " " " 7b.
T'
A' Distance curve from T or T' of c. of gr. Fig 7a.
B " " " " " 7b.
A'
B'
2


SKETCH MAP
OF
NORTH WEST FRONTIER
PROVINCE, INDIA.
Scale, 1 inch = 48 Miles.
Roads
Railways
Boundary of N.W. Frontier Province
70°
72°
36°
34°
32°
CHITRAL
Kala Drosh
Dir
KABUL
JALALABAD
Kabul R.
Kunar R.
BAJAUR
SWAT
Swat R.
Malakand
Mardan
Landi Kotal
PESHAWAR
Nowshera
Attock
Cherat
Hasan Abdal
ABBOTTABAD
RAWALPINDI
KOHAT
Khushalgarh
Samana Range
Kurram
Kurram R.
TIRAH
Thal
Tochi R.
BANNU
Mari
MIANWALI
SHAHPUR
Wana Post
Kajuri Kach
DERA ISMAIL KHAN
Indus R.
AFGHANISTAN
WAZIRISTAN
BALUCHISTAN AGENCY
Zhob R.
CHITRAL
KOHISTAN
PUNJAB
DERA ISMAIL KHAN
Panjkora R.
Indus

PROFESSIONAL PAPERS.—FOURTH SERIES.

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RECENT WORKS IN THE N.W. FRONTIER PROVINCE, INDIA.

BY

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(Lecture delivered at the School of Military Engineering on 10th and 11th January, 1905).

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RECENT WORKS IN THE N.W. FRONTIER PROVINCE, INDIA.

INTRODUCTION.

ENGINEERING Works on the N.W. Frontier of India are important to R.E. officers not only on account of that frontier being the most important in the Empire, from a military point of view, but also because, with few exceptions, the control of all such works, both civil and military, is now in the hands of the Military Works Branch of the Indian Army.

Of recent years both the military and civil administration of the N.W. Frontier has undergone change. Formerly the troops on the frontier belonged mainly to the famous Punjab Frontier Force, commanded by a general whose headquarters were at Abbottabad, and the Civil Government was subordinate to the Government of the Punjab. Recently the Punjab Frontier Force has been abolished and the garrisons of the frontier have been re-organised in accordance with a scheme for the whole army in India.

In respect of Civil Government, a new province has been established, inaugurated on 9th November, 1901. A Chief Commissioner, whose headquarters are at Peshawar in winter and Nathia-gali in summer, has been appointed, with a complete staff to deal with all the varied branches of civil administration, one of which is public works.

The works organisation prior to the formation of the new province was as follows :—There were 3 Military Works divisions under the Director-General, Military Works, and 3 civil Public Works divisions under the Chief Engineer, Roads and Buildings Branch of the Punjab P.W.D. These six divisions have been reduced by re-organisation to four districts (Peshawar, Kohat, Derajat and Abbottabad), one of which, a very small one, may possibly in the future be merged in one of the others. Whether the re-organisation has resulted in better work or not—a matter on which I can hardly offer an opinion—it has certainly resulted in a substantial economy—some Rs.50,000 annually—in the salaries of establishment alone ; and, by bringing all works under one head, it has resulted in an avoidance of the overlapping and undue competition arising from different administrations doing similar work in the same place.

D 2

The Commanding Royal Engineer of the Frontier Province is also Superintending Engineer of Civil Works and Secretary for Public Works to the Chief Commissioner. All officers have both civil and military works to superintend. I found that the proportion of civil to military work was about 3 to 2; but this was mainly due to the fact that, for various reasons, nearly all trans-frontier roads, forts and similar works were styled "civil" when they related to the local militia and police, whereas they were "military" when they applied to regular troops only. This official convention has certain very definite advantages, for the C.R.E. in his civil capacity has much wider powers of sanction than he would have in his military one. Thus important works of defence are in many cases settled much more quickly than would be the case if they had to go through the usual military channels.

The relative duties of the sub-district C.R.Es. (at Peshawar, Kohat and Dera Ismail Khan) and the C.R.E., Frontier, are as follows:—The Sub-District C.R.Es. have all arrangements for the executive work, dealing with contractors, payment for works, and custody of stores. The Divisional C.R.E. does not deal with these except as a supervising officer. He designs all important works, allots funds to the sub-districts, organises and controls all establishments, and inspects works in progress as often as possible. During my tenure of office I endeavoured to inspect all works at least twice a year, but even this limited amount of inspection involved constant travelling from about the 15th September to the end of the following May. One spent nearly the whole of the cold weather travelling, chiefly on horseback, a life which was no doubt a hard one but interesting to those who prefer a saddle to an office chair.

The *personnel* of the frontier defences consists of:—(1) Tribal militia, organised in some 6 battalions of infantry with mounted infantry, officered by British officers; this force is employed in guarding all trans-frontier routes, except Malakand and Chitral. (2) Border military police, also organised as infantry; these guard the actual frontier line against incursions of trans-border tribes. (3) Regular troops at the garrisons of Abbottabad, Malakand, Chakdara, Mardan, Nowshera, Peshawar, Kohat, Cherat, Bannu and Dera Ismail Khan.

Prior to the formation of the N.W. Frontier Province several trans-border posts, now held by tribal militia, were garrisoned by regular troops. The policy of increasing the militia and withdrawing all regular troops to British India of course involved many works both for defence and accommodation. In building fortified posts to be held by militia it was laid down that the work should conform as much as possible to tribal patterns, both on account of economy and because they were understood by the men. The more modern refinements of fortification were discouraged.

Thus, broadly speaking, the problem to be faced in November, 1901, was the design and construction of :—

1. Fortified posts, for Militia and Border Police, at positions selected by the Political Authorities, and approved by the Government of India.
2. The necessary communications.
3. Barracks in selected garrisons for the accommodation of the regular troops liberated by the militia taking over the trans-border work.
4. New residences, law courts, offices and other similar buildings for the officers of the new administration.
5. Collateral works, such as water supply and drainage, involved in the above.

In this paper I have only time to touch upon :—1. Fortifications; 2. Roads and bridges; 3. Certain civil buildings of a special character. Barracks—which formed a large item in the foregoing programme—and other collateral works must be omitted on account of the limits of time.

DEFENSIBLE POSTS.

In dealing with the design of any sort of fortification the first consideration is invariably the nature of the enemy and his weapons. On the N.W. frontier the enemy is certain to be an adept in the art of creeping up close to the works, utilising to the best extent accidents of ground. The attack will not necessarily be delivered openly nor in an organised body, but the enemy is quick to ascertain where an imperfect lookout is maintained, and where he is safe against fire. His chief aim being to steal a good rifle, he will undertake many risks and will not hesitate to commit any *ruse de guerre* to gain his object. If a whole tribe is roused, or if there is any leader of outlaws who desires to deal a severe blow at the prestige of the ruling power, they may attack a post in force. They are skilled at all arts of escalade and are quick to discern a weak spot in the fortification. Equally are they adepts in the art of digging through a wall, and they are usually well armed and good shots.

Two instances in modern times have been a most valuable guide to us in the design of frontier defences.

At Saragarhi, a post on the Samana ridge, there was on 10th September, 1897, a most determined attack by a large body of tribesmen on a tower held by 1 N.C.O. and 20 men of the 36th Sikhs. The tower was built of stone in clay mortar, but I understand that the machicoulis were so imperfectly placed that at certain points the enemy could come close up to the wall and work with perfect safety at pulling out the stones of which it was built. Some of the enemy did effect a breach in this way, and in the murderous hand-to-hand fight that ensued every man of the garrison was killed.

At Gumatti village, some 8 miles from Bannu, there had been built by the tribes a post with sun-dried mud walls, which, on the 17th November, 1902, was held by 6 men armed with Martini rifles against 300 of our best troops and mountain guns for something like 6 hours. It was captured eventually with a loss of 2 officers killed and 5 wounded and some 40 casualties among rank and file. Lieut. C. M. Browne, R.E., distinguished himself by conspicuous gallantry on that occasion.

The lessons learnt from these two cases are :—

(1). It is absolutely necessary to have posts that will not allow a single square foot of dead ground outside.

(2). It is possible to construct with local materials posts which, if held by resolute men, will resist anything short of high explosives.

Walls.

In the case of Gumatti the walls were made of clay laid in layers about $1\frac{1}{2}'$ high. Baked by the fierce heat of the sun this material becomes extremely hard; but it takes a very long time to build, for the essential point is that one layer must be absolutely dry before the next is put on. Such work is frequently prohibitive for our purposes as we cannot as a rule afford to wait, though when we can do so the walls so built are very cheap and very effective. Sun-dried brickwork is more expensive, but it is equally good and as a rule is more frequently used.

To defeat the operations of the digging thief, the natives usually build their towers on a base of some solid material. The door is entered from a light ladder which is pulled up at night. Of course the same object is attained by building the lower part of the tower in stone or burnt brick laid in substantial mortar. Recently the experiment has been suggested of building into the sun-dried brickwork a vertical line of expanded metal.

Machicoulis.

As regards machicoulis, it seems to have been thought at one time that only steel plates should be used. But this material has the disadvantages of great expense, both in first cost and in transportation to site; it may deteriorate if not constantly attended to; and it is doubtful whether after some little time the steel is not penetrable by short range fire. The case against steel machicoulis is a strong one.

After several experiments we found that there were practically only two sorts that were worth considering, both of which could be made up locally. One is that used at salients, consisting of a frame of stout timbers well bolted together; through the floor one can see along both sides, and from the flanks one can fire through skew loopholes; the sides are built up of brickwork (see *Plate* XV.). The other sort is adapted for use in the centre of a face; the gallery is supported on gallows brackets, and the parapet formed either of sheet iron or of planks, with earth rammed between, or of brickwork. If there is any possibility of the brackets being reached by climbing they should have barbed wire wrapped round them.

Parapets.

Another detail is the height of the parapet. Recent experience in war has shown the absolute necessity of head cover, and this cannot be always improvised when needed. Primarily therefore the parapet should be at least 6′ high, and loopholed in accordance with the requirements of the defence. Crenellations are of no use against men practised in escalading by means of a rope and a short stick. The stick catches in the crenellations and the rest is easy. So head cover must be given. But if that were all, the sentries could not possibly keep a lookout at night. Raised platforms at salients only were tried, but they have been found, generally speaking, insufficient. So a rough banquette of timber has recently been ordered, so constructed that it can easily be pulled away if necessary. This banquette is high enough to allow a sentry to look over the wall easily at all points of his beat.

Gates.

The entrance gates in important works have to be made of steel. I do not know any other way of rendering them bullet proof, though one would willingly avoid the expense and trouble of getting steel gates made and sent to isolated spots. In posts of lesser importance, it is usual to make the door of wood. The enemy will not waste ammunition firing at a door unless he feels sure he will hit someone behind it; and if the door is narrow and well placed in a re-entering angle, bullets, even if they do penetrate, are not likely to do much harm.

Principles Design.

The broad principles of design are:—

(1). The perimeter of the work must be as small as possible.
(2). There must be as few sentries as possible.
(3). There must be no dead ground outside.
(4). The work must be properly defiladed.
(5). The design must be simple.

There are also of course the usual considerations of accommodation, water supply, drainage, storage for provisions and ammunition.

You may perhaps wonder why I have gone into the consideration of details and principles to such an extent in a matter which probably anyone of common sense would agree to. My reason is that all the above considerations, when taken together, mean efficiency combined with economy. When I tell you that we were able to reduce the average costs of frontier posts from about Rs.400 per man to less than Rs.200 per man, you will admit that economy in design is worth studying.

The works one may be called upon to design vary from a large headquarter fort to a blockhouse or tower for 8 or 10 men.

Taking the smallest first, there appears to be no object in departing from a square plan. There are some good towers built on a hexagonal trace, but there are no special advantages and certain definite disadvantages in this pattern.

The square form is easily flanked by two corner machicoulis (*Plates* I., *Fig.* 1, and XV.) and it is simply and cheaply built. If the post is situated in a very hot locality or if it is commanded by a neighbouring height, it is easy to make a roof over the upper part, which will screen from observation as well as from the sun. It is often necessary to send mounted messengers to such posts and accommodation for 1 or 2 horses for the night is desirable. This is given in a little ravelin outside.

The floor of such a post should be raised at least 4′ above ground, the space being utilised for a water tank, provision boxes, etc. (see *Plate* XV.).

The area per man should be 40′ at least, better 50′. In former days 30′ only was allowed but this is far too little.

The roofs are made of round spars, 3″ to 5″ diameter and 1′ apart, covered with matting over which is laid 3″ or 4″ of earth, the top surface being smoothly plastered with a fall of 1 in 40 to shoots or gutters at the sides. As the spars can only be trusted to span about 8′, some intermediate support is necessary. Trussed beams are the cheapest and most convenient form. Rolled steel beams are effective but dear.

The walls should be at least 18″ thick of sun-dried brick. If stone is used most careful bonding is necessary. Loopholes should in all cases be carefully made with reference to the ground visible from them. From experiments made at Kohat we found that stone loopholes splintered badly under rifle fire.

When a post has to be built for a garrison exceeding 10—12 men, the trace can either be two towers connected by a defensible barrack, the towers mutually flanking one another, or two rectangular towers can be built communicating with each other (*Plate* XVI.).

A shelter for horses can be given in the re-entering angle on one side and a cooking shed on the other.

The two towers connected by a barrack are suitable for the crest of a hill where a single tower or the double rectangle would not cover the whole.

When the post requires a garrison of more than 50, it will probably be necessary to find room for 1 or 2 British officers (*Plate* XVII.). Probably such a post will not be perched up on a hilltop but near some main road. Some defilade may be required. If it is on a hilltop, the plan of 2 towers with a defensible barrack joining them may be adopted. One of the towers can be utilised for officers' quarters. The stables can be near the connecting barrack.

Bearing in mind the principle that the perimeter is to be as short as possible, there will be considerable advantage in making the buildings in some cases double storied, putting the quarters for the fighting men above and those for the non-combatants below. Rifle thieves will not waste time in trying to dig through walls when there is no chance of stealing weapons.

Officers' quarters should not be placed on the outside of the post, unless the back of the quarters faces north and even then it is not very satisfactory. The reasons for this are :—The exigencies of the climate demand that every house for Europeans should have a verandah to protect it from the sun, and each bedroom should have a bath room opening out of it, with a separate door for servants. One cannot have the *front* of officers' quarters on the defensive line for obvious reasons, and if the back has no verandah it will become intolerably hot unless it is facing north. In such a case the officers' quarters may be on the defensive line ; but this will necessitate all servants' quarters, kitchens, bath rooms, etc., being either to the front or so near as to be in no case a nice arrangement.

As regards horses, I think all animals should be stabled in a separate ravelin or hornwork (as in *Plate* XVII.), approached from the inside of the main work. As regards the interior defences, opinion was formerly much in favour of a *reduit* or keep, and some of the recent defensive works were arranged with that idea. But latterly this has been given up, as it is considered unsuitable for imperfectly disciplined troops.

In a large post designed for the headquarters of the militia in a certain district the troops are in double-storied barracks, arranged so as to flank the sides. Officers' quarters and mess are inside, horses and transport animals are in a ravelin. The political officer and civil staff occupy a small separate enclosure, flanked from the main work.

The general arrangements for such a valley as the Tochi are :—

(1). Headquarter post in a suitable position near the centre.
(2). Near the chief raiding routes strong posts, say from 50—100 men each.
(3). A group of posts near the end of the route, about 10 miles apart, visible from one another, so that visual signalling may be carried out, and enclosing a considerable area within which no hostile force can collect.
(4). Small posts or towers all the way down the valley, from which signalling can be kept up, and which watch side valleys where bands of robbers may approach.

The cost of these posts depends to a slight extent upon their isolation and to a very great extent upon the materials. It is obvious that, if a post is built in a far-off lonely spot, it will be relatively expensive. And if, instead of using the local materials, the work be built with steel joists, steel machicoulis, planed and squared timber, etc.—as has been the case in some places—the cost will be more than double compared with the prices I am now about to quote. Cost.

Using local materials, such designs as I have described cost from Rs.120 to Rs.180 per man of the garrison—a small post costing relatively more than a large one. For each native officer or civil employé the allowance should be twice that of an ordinary soldier, and for each British officer Rs.2,000 should be allowed. With these data approximate estimates of the cost of works can be furnished with fair accuracy.

ROADS.

I now pass on to the next division of my subject, viz. :—roads. Three long and most important mountain roads have been made in the trans-border country during the last 3 years, their lengths respectively being 40, 62 and 87 miles.

Besides these the whole of the Trunk road through Hazara to the borders of Kashmir was re-aligned and graded, and metalled—a large and important work ; and there were a number of smaller lengths of road at other places.

Preliminary Estimates.

I have explained that all arrangements for actual execution of work fall to the duty of the Sub-District C.R.E. This fact, which is true in every case, is especially true in the case of mountain roads, because there, as will be readily understood, at every yard of the road the local conditions of soil, drainage, etc., vary. Of all the estimates which an engineer may have to submit, a mountain road is the most difficult to forecast with accuracy. Often the ground which has to be traversed is inaccessible and the nature of the soil has to be guessed. As the cost of excavation of different sorts varies by something like 700 %, and as such excavation forms the greater part of every hill-road estimate, it is clear that a faulty guess may in many cases mean an enormous difference in the total cost. This is more the case with roads than with railways, because in the latter a large proportion of the cost is made up of permanent way, stations, rolling stock, etc., so that an error in estimating the value of the earthwork does not make the same relative difference in the whole. In the case of buildings or forts, the cost of the work can be readily estimated from measured plans. With roads everything depends on the officer in charge carefully watching whether the actual cost is agreeing with the estimated figures as the work progresses. From this it will be evident too that the more care and time spent over preliminary investigation, the less chance will there be of mistakes afterwards.

Another point that should be remembered in connection with hill-road construction is that the cost of the road varies as the square of the width. Now if a road is ordered to be 8′ wide that does not mean that an excavation 8′ wide has necessarily to be made in the hillside. Probably 4′ would suffice, the excavated earth making up the balance. And a road 4′ wide will only cost 25 % of the price of the 8′ road. Hence it is always wise to make first a narrow road all along the approved alignment, and then to widen it out as funds admit.

The necessity for extreme care on the part of the local officers was exemplified in two of the large roads mentioned above, and they form so valuable an object lesson that I think a brief description of each case is desirable.

Arrangements well worked out.

The first road had been carefully surveyed and estimated in the winter of 1888–89. Time and pains had been expended on the preliminary investigation, and so carefully was the work done that when (14 years afterwards) it became necessary to carry out the work, all the preliminaries were found to furnish an invaluable guide.

Owing to political reasons the work was not begun till the winter of 1902–03. The road, originally estimated for a 24′ width, was ordered to be 8′ wide as a preliminary. It was subsequently widened to 16′. Part of the line passed over rough and precipitous country. It was wisely determined to devote special attention to the difficult parts, for these would obviously be most expensive and would take the longest time to do.

It was also desirable to give the tribesmen, through whose territory the road passed, a direct pecuniary interest in it; and as they would know little about the niceties of measured contracts, it was considered best to give out the work in definite lengths at certain agreed sums.

The Sub-District C.R.E. himself personally supervised the work and all arrangements connected with it. In conjunction with his native assistant, a man specially deputed by the political officer on account of his tact and influence with the tribes, the C.R.E. offered definite lump sums to certain headmen for the execution of the portions of the work passing through their territories. At first they seemed a little suspicious of interference with their independence and they took up the work cautiously; but as they realised that they were regularly paid, and that money flowed in to them freely at remunerative rates for their actual labour, they willingly came forward and did further work expeditiously. Every detail was arranged so as to make terms easy for them; *e.g.*, they were paid at frequent intervals in hard cash and not in cheques on a distant treasury, tools were given for their use, and a limited quantity of blasting powder was issued free of charge. The C.R.E. himself constantly spent days on the work going into all finances and checking expenditure.

Note therefore the following excellent arrangements:—

1. Very careful initial alignment and complete plans and estimates.
2. Lump sum contracts based on estimated quantities.
3. Payments in cash at regular and frequent intervals.
4. The most difficult parts tackled first.
5. The work begun on a narrow width and afterwards widened.
6. Constant inspection and careful checking of expenditure by C.R.E.

Arrangements badly worked.

The other road, 62 miles long, was carried out on almost diametrically opposite lines. The road itself traverses a much more difficult country than in the previous case, and, instead of being near the headquarters of the sub-district as was the case of the other road, this one was 60 miles from headquarters at its nearest point.

There were other initial difficulties. At the outset the estimate had been based on a very hasty reconnaissance, it was admittedly approximate, and it was unquestionably very low. It had been cut down from its original amount by superior authority, who ordered the local officers to make the best road they could for a certain sum.

At the time of the original scheme, 1901–02, we were at war with the tribe occupying that part of the country and a detailed examination of the route was impossible. This was the reason of the hasty reconnaissance above-mentioned—a bad start to begin with. A regiment of pioneers was sent to make a beginning on the road; they however did very little work and the cost of their movements, clothing, etc., was a heavy burden against the exiguous finances of the road. Still further to complicate matters, when at last peace had been effected and the arrangements for a busy working season were complete, at a time too when the military authorities were pressing for the completion of the road and the politicals anxious to find work for the tribesmen, the Sub-District C.R.E., in spite of protests, was ordered off first to manœuvres and then to another station and was not replaced. So the burden fell on the shoulders of his *locum tenens*, a captain who was already overworked and whose only subordinate officer was a civilian temporary assistant.

The crux of the whole was a gorge, some 18 miles long, where a river forces its way through the mountains. In some places the only means of getting through was by swimming. Laying out the line at the necessary height above flood level—a considerable height in most places—was specially difficult. Here and there it was possible to scramble along ledges and over cliffs, but in other parts all that could be done was to note a bush or crag and, having fixed that as the general line, observe with some instrument and see whether it came within the admissible gradient.

The tribe, through whose territory this road passes, had concluded a peace with the British Government shortly after the road work was begun. As they had cut up a road party a few months before, there was a certain amount of natural reluctance on the part of native subordinates to go there again, and this fact added considerably to the local difficulty in carrying on the work, as it was impossible to get really good men to go to the place. However, both civil and military authorities were anxious to have the road pushed through, and orders were accordingly given to have the line carefully laid out and an investigation made into the finances. I visited the work in November, 1902—the gorge portion being then untouched—and lecided on the alignment and on the sum available for work; also arranging with the political officer for labour from our quondam enemies, to whom it was considered desirable to give work in order o keep them out of mischief.

The assistant engineer, who was left in local charge, did the work of engineering well, but he quite lost touch with the finances and he was unequal to the task of managing the unruly tribesmen. From eports I received I was under the impression that little work was being done; but on hearing, after some 2 months, grave complaints of the temper of the people owing to their being irregularly and nsufficiently paid, I revisited the work, and found that an immense number of men had been put on and that an excellent but unnecessarily wide road had been made in all the easier parts whilst the difficult precipice work had been left severely alone. Moreover nobody seemed to know what the liabilities were, and indeed the contracts with the people were of the vaguest description. When hey *were* paid they were given cheques on a distant treasury, and all sorts of deductions were made on account of tools, explosives, rations, etc.; so that not only were the people irritated but the inances were in chaos. I had to stop the work and order thorough nvestigation. On measurement it was found that the liabilities amounted to an enormous excess over authorised expenditure, which of course resulted in severe censure to those principally concerned.

I mention these facts as a warning. You will see that there was:—

1. A very rough and insufficient estimate, which, owing to the pressure exerted to get the road finished, was never properly supplemented by an estimate in detail.
2. Measured contracts based on the various sorts of soil.
3. Payments by cheque long withheld and in arrears.
4. The most difficult parts left undone.
5. The work carried out to more than the maximum width. Of course if the funds had admitted of this being done throughout I should not have objected, as the orders were to make the best road for the money, but it was utterly wrong to do it until everything necessary to make a fair passable road throughout had been complete.
6. The acting C.R.E. very seldom visited the work.

The third road which I shall briefly describe passes through a most difficult defile in the mountains. The first portion of it crosses a broad arid plain, which in dry weather presents no obstacle but after rain is quite impassable. The country is very sparsely populated, and is intensely hot in summer. It is scarred and furrowed by numerous ravines, ordinarily dry but quite unfordable after rain. Therefore the chief work in this portion was the bridging of these ravines, a matter which I shall deal with later on.

Some 43 miles from its starting point the road enters the hills and ascends a valley. The survey and estimate for this part had been very carefully worked out prior to November, 1901, but no work was actually started. No sooner had it been begun, early in 1902, than there was a rising of the local tribes. They murdered the principal native official, blew up all the dynamite collected for the work, and generally behaved like savages. It was hopeless to start again just as the hot weather was beginning. As soon as the weather cooled I sent down a most energetic and capable R.E. subaltern, who tackled the work with great tact and skill, restoring confidence to the workmen and making friends with the tribes. His arrangements were based on measurements, but at the outset he made careful and definite agreements with one or two big contractors as to rates of payment, and he was particular to pay regularly and with due regard to the convenience of the people. The result was very successful.

There was a great deal of precipice work on this road and in the upper regions the line had to be taken through a very difficult gorge (*Plate* I., *Fig.* 2). The arrangement for bridging this gorge will be described later.

Approximate Estimates for Roads.

I would, in conclusion, say a few words about approximate estimates for hill roads. If you are ordered to make a reconnaissance of a valley or pass for a road, remember to examine the country for some distance on either side of the ordered route. Not only will it sometimes be possible to introduce economical diversions but it may result in the discovery of valuable material. On one road we came upon a quite unknown quarry of pure white marble. On the Kashmir road I was told by an officer of much experience that we could not possibly get good road metal anywhere near; but another officer, not nearly so experienced, whilst pottering about the country, found an ample supply of good and cheap material. The result in this case was a large saving on the estimate.

All these points will affect the estimate, but one is frequently called upon to submit approximate estimates with the least possible reconnaissance. For instance, after the fighting at Gumatti in November, 1902, I was ordered to telegraph the cost of making a military road through a pass which I had never even seen. I knew that the distance was 8 miles and that the first 4 were very easy. So taking the 4 difficult ones at Rs.4,000 a mile each and the others at Rs.1,000 a mile I arrived at Rs.20,000 and telegraphed accordingly. The work was done within 12 months for Rs.17,000.

Of course the width of the road is the important factor. In the case just mentioned the road was cut to 6′ width in full cuttings, which is sufficiently wide for army transport carts or field guns; but in side cutting this gives about 10′ width. The bridges are 10′ between parapets.

A commercial road would have to be wider. For camel traffic it should be 12′, and for carts 14′ to 16′.

The cost of a camel road is about Rs.7,000 a mile in rough hilly country. Cart roads cost from Rs.8,000 to Rs.10,000 or Rs.12,000 in such country. For precipice work, of course, such rates would be quite inadequate. There the cost runs up to Rs.50,000 a mile.

A first-class metalled road, 16′ to 20′ wide, metalled and bridged throughout, costs from Rs.20,000 to Rs.30,000 exclusive of large bridges. These may roughly be estimated at Rs.120 per foot run of length.

The gradients for wheeled traffic or camels should not be steeper than 1 in 15 and it is better to make the steepest gradient 1 in 20. It is true that a laden camel can go up a much steeper grade; but if, as is probable, the marches are long, he will break down altogether if he has many steep places to negotiate. It is the opinion of far more experienced men than myself that on a regular line of communication the gradient for a camel road should be the same as for carts.

If one can avoid a zigzag or shorten the length of a march by putting in a short and straight, though steep, piece, it may be an advantage to do so, because all animals can do a short spurt without materially affecting their well-being. For artillery it is specially desirable to avoid zigzags. This is one of the weak points in the first of the roads described above, which is full of them; on the second road there is hardly one.

Finally remember the necessity of having halting places at regular intervals with a good supply of water. This consideration often turns the scale in the selection of a route which in other respects may appear to be disadvantageous.

Explosives required.

As to the quantity of explosives used on rock blasting, the actual quantity excavated on a certain bit of precipice work was 438,000 cubic feet. The explosives used were:—English blasting powder, 2,050 lbs.; country powder, 5,000; dynamite, 750 lbs.; detonators, 3,300; and 47,000 feet of Bickford's fuze. As the country powder is about $\frac{1}{5}$th the strength of English, we may estimate 3,000 lbs of the latter to 438,000′ of rock, or say 1 lb. of English powder to 150 cubic feet. Powder is more useful for rock cutting than dynamite as it splits up the rock rather than shatters it, and thus the excavated material may be used in walls.

BRIDGES.

Small bridges on hill roads are usually formed of masonry abutments and wing walls—the latter often built without mortar—spanned by rolled steel joists or rails, laid at about 2′ intervals, the decking consisting of 2 layers of corrugated iron sheeting covered with gravel and earth. The railings are best made of angle-iron standards with gas-piping for handrails. Wooden railings should not be used because they are very frequently stolen in a country where wood is scarce.

Where masonry piers can be easily and inexpensively built, a bridge of many spans formed in this way is very suitable. But there are localities where building materials such as bricks or stone are not procurable, where there are no facilities for workmen to live, and where even the ordinary necessaries of life have to be imported. Such a description applies to the waste barren stretch between Dera Ismail Khan and the foot of the hills, where the line of the road crosses a series of ravines which in rainy weather are impassable.

Steel Trestles. The method adopted there is to have a type of bridge supported on steel trestles (*Plate* XVIII.), designed for spans of 25′, so that the actual bridges could be arranged in multiples of 25′, and the height of the trestles could be made to suit the depths, a matter of very easy arrangement and not varying much.

It is easy enough to get firms in Bombay or Karachi to make up all the ironwork complete, and thus the actual building of the bridge at the site takes a very short time. The only actual building material required, other than the trestles and superstructure, is the concrete for the bases of the trestles and the abutments; so that the expense and trouble of sending materials to a distant spot and of housing workmen there is reduced to a minimum.

The only difficulty would be the carriage of the iron pieces to the site, but in this instance this was not worth considering as a cart track exists for fair weather. But it would render this style of construction almost prohibitive in a mountain road where everything has to be carried on camels. There it is of advantage to use stone or bricks for piers.

Rolled Steel Beams with Masonry Piers. A conspicuous instance of the use of steel beams on a large scale is afforded by the Dore Bridge near Abbottabad (*Plate* II.), where there are 19 spans of rolled beams supported on masonry piers and carrying a roadway of tarred wooden sleepers. This bridge was designed prior to November, 1901, and the ironwork was all ordered from England when I took over the works. The design was very carefully worked out; and it appeared from many comparative figures estimated by the designer that 30′ spans with timber decking would be the cheapest. But he went throughout on the assumption that it would not be necessary to take the foundations to a greater depth than 12′, that the quantity of water which would percolate into the excavation would be small, and that no cement would be required in the masonry.

These assumptions were unfortunately wrong. The stream here passes through a trough-like depression, between bluffs some 30′—40′ high. This channel in time of high flood is filled from bank to bank with a discharge of something like 78,000 cubic feet per second and a calculated velocity of 16·6 feet per second. As the design reduced the waterway from 4,700 to 3,500 square feet, it was evident that the increased velocity due to the restricted waterway would be enormous, and that the swirling and scouring action on the downstream side of the piers would be such as to threaten to a serious extent their stability. The work had been hardly begun when I made my first inspection; and it was then quite evident that extensive pumping would be required, and that to construct the foundations without cement mortar was out of the question. I therefore considered it my duty to stop the work, pending report to the Government of India to whom I explained the whole case. The result was that the Government ordered a floor and curtain wall to be built, the latter being 20′ deep and 5′ wide, to protect the piers against scour. This of course added enormously to the cost. The construction of this huge curtain wall crossing the bed of the stream was a matter of great anxiety and difficulty, involving as it did extensive pumping plant and arrangements for a large supply of materials by a temporary railway from the quarries. There were frequent interruptions from floods. The work however was carried out with a substantial saving on the estimates.

Time does not admit of a detailed account of this very interesting construction. One point which I wish, however, to emphasize is that it would have been much more economical to build this bridge with deep foundations—say 20′ in each case—and spans of 80′ to 100′ lattice girders.

In the case of a tributary stream, the Salhad, which joins the Dore just below the big bridge, where excavation to a depth of 14′—16′ revealed no influx of water in normal weather, it was found most economical to use 40′ lattice girders. This was the conclusion arrived at after working out designs for rolled beams, plate girders, lattice girders and arches.

Lattice Girders with Masonry Piers.

The largest bridge built during my tenure of office as C.R.E. of the N.W. Frontier was that named after H.R.H. the Duchess of Connaught (*Plate* III.) over the Swat River at Chakdara, which has been fully described by the officer in charge, Capt. H. Biddulph, R.E., in the *R.E. Professional Papers* of 1903. The spans are 5 of 160′ each, and the depth of the foundations 34′.

There are one or two points, omitted by the author of that paper, to which I would draw attention in connection with the subject of bridge design. The girders themselves, designed and constructed by Messrs. Richardson & Craddas, of Bombay, have some practical defects. One is that the girders have long tension members, formed of two parallel plates unconnected throughout. Theoretically it is all right to have two tension members, each charged with doing half the work. Practically it means that, unless the members *exactly* correspond, the one which is the shorter will have all the work and the other will be useless. This of course could be guarded against by a light bracing between the members. Another point is that the fastening of the members to the lower booms, which are composed of vertical parallel plates, is by means of knuckle plates at right angles to the general line of the bridge. Now unless the angle be absolutely true, the parallelism of the vertical plates will be thrown out.

It may be well to bear these points in mind in the event of your having to pass stores at the place of manufacture. When complaints were made to the manufacturers their reply was that the girders were inspected and passed by an R.E. officer at Bombay, prior to despatch—a very legitimate argument, of course. Hence if any of you are detailed for work of this sort, it is most necessary to insist on the utmost exactness in work before it is passed.

Another defect in this design is the great distance (5′) between the road level and the bottom of the boom. The latter being a fixed quantity, owing to its being at a certain distance above highest flood level, it is for obvious reasons desirable that the distance to the roadway should be a minimum so as to reduce the height of the approaches.

Arched Bridges.

An arched bridge is the most satisfactory form of all if it can be built at a reasonable cost. It lasts for ever, and requires very trifling periodical repairs. In places where the transport of steel is costly, and where stone can be quarried easily, it is also relatively cheap. In the crossing of the Kharmana in the Kurram Valley (*Plates* IV., *Figs.* 1 and 2, and XIX.) the comparative cost of girders and of masonry was carefully considered, and the balance was decidedly in favour of the latter, as a good quarry was found within a mile of the site.

In Northern India there seems to be a strong predilection for very flat arches in all bridges. I can understand why this should be the case in irrigation canal bridges, because there the water level is generally about the same as the plain which it irrigates, and a bridge with the necessary headroom is an expensive structure under any circumstances. The lower and flatter the arches, the cheaper the bridge. But of course the flatter the arch, the greater is the lateral thrust on the abutments. *Cæteris paribus* therefore it is better to give an arch with a good rise.

Flat Arches risky.

Why flat arches should be so universally used in ordinary roads in the Punjab P.W.D. I never could find out. The fact however was brought very forcibly to my notice in connection with several of the bridges built about 1888–90 on the N.W. Frontier Road between Kohat and Bannu (*Plate* XX.). These bridges are architecturally very handsome, but I noticed that every arch had settled perceptibly some inches. Examining the arch rings, built of sandstone ashlar, I found every one was crushed about the same place at the soffit near the springing; and on working this out approximately the pressure amounted to 4 tons per square inch, the ultimate strength of certain sandstones being 1 ton only. This form of construction is also faulty in that it necessarily brings a great horizontal stress on the masonry of the abutments, tending to shear the mortar along the joints.

Some years ago I made a series of experiments with full-sized arches built of brick without any mortar, with the object of seeing whether, in an ordinary arch, reliance has to be placed on the tenacity of the mortar at any part. I was at that time building a large number of bridges and was ordered to strike the centerings as soon as the arches were keyed up. This I respectfully protested against on the ground that, the line of resistance of an arch being a parabolic curve and the actual line of the arch ring being circular, there must be in some parts such a divergence of pressure from the centre of the arch ring that reliance on the tenacity of the mortar is inevitable. Thus far theory had pointed, and the question was whether practice would corroborate theory. The corroboration was startling in its exactness. Throughout the arch it was possible to trace the line of resistance by the visible pressure on the bricks. At some places, notably at the intrados at the crown and the extrados at the springing, the bricks were quite loose and were doing no work at all. When the arch was built in concentric rings, these were all separated and distorted.

These experiments, following careful theoretical investigation, convinced me that in the design of bridge arches we should follow a curve not far different from a parabola and with an ample rise; that we should allow the mortar some little time to set before striking the centres; and that we should use bricks laid in such a manner as to give a thorough bond to the arch ring.

On these principles the design of the Kharmana bridge (*Plate* XIX.) is based. The rise is one-fourth of the span (40′). The arches were in every case given at least a week before the centres were struck; and the bricks were arranged with two sorts of tapering bricks, of an equal size to ordinary bricks, so as to give a bond transversely and longitudinally. The latter arrangement was, I may say, not only theoretically sound but it is extraordinarily economical, as there is no chipping and dressing of the bricks when placed in the work.

The reason why two abutment piers were given is that the bridge was built in three parts or groups of arches, the end groups being first built, with diversion works training the current of the river through the central portion. When the end groups were completed, the current was diverted towards them, and the central group then completed. The little arch at the end was to allow an irrigation cut to pass under the bridge to some fields on the lower side.

A little attempt was made to introduce architectural variety into the design by continuing the abutment piers above the line of the parapet and thus breaking the continuity of that line, while at the same time affording a recess for passengers over the long bridge (*Plate* IV., *Fig.* 2).

In mountain gorges where building material can be obtained without difficulty and bricklayers or masons can be sent to the spot, arched bridges can often be usefully employed. *Plate* XXI. shows one built on the Gumatti Pass road, materials and labour having been sent out from Bannu. The rock in this case lent itself to the erection of the centering, but in some cases this is not so.

Cantilever Bridge.

The most notable case of special arrangements having to be made for bridging a gorge was at the Churkhel Dahna defile, which is situated in a most lonely and inaccessible spot. An attempt some 13 years ago to make a road at a high level through this defile was unsuccessful and resulted in a terrible accident. Another attempt to take the road through the gorge below flood level ended in the road being completely wiped out. It appeared to me after careful examination that a practicable road could be made at a high level, if only we crossed the gorge twice. The height of the crossings would prevent bridges being built on centerings or staging in the bed of the stream; suspension bridges were unsuitable for camel traffic on account of oscillation; lattice girder bridges would be difficult to transport to such an isolated position, and difficult to erect. So it was resolved to try a cantilever bridge, as shown on *Plate* XXII.

The uprights or portals on each side were erected on walls in which hinged struts had been built. These struts hinge at their outer end on the centre of the main road bearers, which are launched with ropes over the main standards. Then long inclined struts are secured, over which pass permanent ties to the ends of the main road bearers. These struts are stayed at the bottom and cross-braced above. The ties passing over the main portals are anchored to the rock behind. When these operations are complete on either side, the central portion is easily put in.

To guard against the loads of pack animals jostling against the main ties, the roadway in the centre is made at a different level from that at the sides, and wire netting is given to a certain height. This form of bridge is relatively cheap and each component part is designed so as to be carried on camels. I regret to say I left the country before any of these bridges were finished but I have since heard that they are quite successful.

Paved Crossings.

Frequently in hill roads paved crossings or "Irish bridges" are used. These, if on a rising grade, should be arranged so that there is a level portion on either side; otherwise the water will pour down the road on the lower side and wreck it. The apron of stones below the crossing should be very massive and built in steps at a general slope of about 2 over 1, so as to break the force of torrents.

Although time does not admit of any detailed account of the actual construction of the various bridges mentioned above, with its record of difficulties encountered and overcome, I hope that the mere description of different sorts will be a guide to those of you who may have hereafter to undertake work in similar circumstances. One uniform type of bridge is not economical, nor is it true engineering to adopt always the same type under all varieties of conditions.

CIVIL BUILDINGS.

Though under the generic head of civil buildings are included jails, court-houses, travellers' rest-houses, public offices, police stations and many other similar works which had to be carried out in various places after the formation of the Province, I propose to confine myself solely to the description of the headquarter buildings, which were of a special character.

When the new Administration was decided upon, in 1901, one of the first and most pressing needs was the provision of houses for the Chief Commissioner and his staff of officers, and of law courts and other offices for the Administration. The province was inaugurated on November 9th, and some 5 weeks before that date, Mr. Macdonald, one of the senior executive engineers of the Punjab P.W.D., was specially sent to Peshawar to prepare a scheme for the new Headquarters. He left the place on the 15th November handing over to me all his papers, and considering the very short time he had been in the place it was marvellous what an amount of work he had done. He had worked out in outline a scheme, which in all except a few minor matters, has since been completed very satisfactorily. It was submitted, with an approximate estimate amounting to some $5\frac{3}{4}$ lakhs of rupees, in December, 1901, accepted with some modifications by the Government of India in January, 1902, and completed in every respect, with a substantial saving, in March, 1904. What that scheme was I shall now describe.

The requirements of the new Administration were :— *Scheme for Civil Headquarters, Peshawar.*

1. Government House—the residence of the Chief Commissioner, with suitable park, gardens, stabling, servants' houses and other accessories, including a guest house for some of the many visitors whom the Chief Commissioner has to entertain.
2. Law Courts for the highest courts of appeal.
3. Offices for the Chief Commissioner and his secretaries.
4. Offices for the heads of departments, police, medical, public works, and education.
5. Residences for the seven principal officers, viz., the Judicial and Revenue Commissioners, the Inspector-General of Police, the Administrative Medical Officer, the C.R.E. and Secretary, P.W.D., and the first and second Secretaries to the Chief Commissioner.
6. New printing office, new roads, water supplies and other similar matters.

The estimated cost for the whole of the above was at first sanctioned at 5 lakhs, but was subsequently raised to Rs.5,42,000 or say £36,000. It was carried out at an actual cost of I think Rs.5,16,000, say £34,000. On about £8,000 of this a revenue in the shape of house rents, at a clear $3\frac{1}{2}$ % is obtained. Thus the total cost to the country is about £26,000.

Mr. Macdonald of course had only time to consider the scheme in its broad outlines, *i.e.*, the size and general arrangement of the buildings, their site and relative position, and to submit an approximate estimate. He worked out a few designs also which served as a most useful guide, but none were actually carried out without extensive alteration. The credit of the scheme in its broad features, however, certainly belongs to him. The credit of its execution with such rapidity and economy and its suitability to its purpose belongs to Capt. H. S. Rogers, R.E., now at the War Office. This officer was specially placed in charge of the work from May, 1902, and at great personal inconvenience to himself he stayed until it was almost complete in October, 1903. Had it not been for his unceasing vigilance over funds, his careful selection of workmen and materials, and his excellent knowledge of engineering, I should indeed have been in difficulties, for the C.R.E., Peshawar Sub-District, had more work than he could overtake, and so I was obliged to take the work under my own immediate superintendence in addition to my other duties.

Government House, Peshawar.

There had been, prior to 1901, on the present site of the Chief Commissioner's house an old and not very commodious building used as the residence of the Commissioner of Peshawar. At one side of this building there was a public road bordered by a collection of dirty servants' houses. At the back was the Cantonment slaughter house and the remains of a Mahommedan graveyard.

On the formation of the new province, the Chief Commissioner naturally insisted that the slaughter house and the servants' houses should be removed, and that the existing house should be remodelled and enlarged. New slaughter houses chargeable to the General Scheme were of course built on a distant site, and a plan was sent in for the enlargement and improvement of the existing house. But an alternative proposal to pull down the old house and build an entirely new one was subsequently sanctioned. This was a much more satisfactory way of dealing with the matter than tinkering up the old house, and the increase in cost was not very serious.

Our orders in respect of this house were :—to submit a plan, leaving the architectural treatment to the experts at Simla. The plan finally approved of and for which I am only partially responsible is shown in *Plates* V., VI., and XXIII. It has proved to be admirably suited for its purpose, so much so that in every respect save one it might serve as a useful guide for similar work elsewhere. The salient points of the design are :—

1. A large and ornate central hall, fitted with a dancing floor, and with gallery and balcony. From it open drawing room, dining room, billiard room, one bedroom and office.
2. The drawing room, being the principal reception room, is wider and generally larger than would be the case in a wholly private house.
3. There is a music gallery in the dining room at the end nearest the hall, arranged so that a band there provides music for dancers both in the dining room and the hall.
4. There are straight passages through the house, providing through draught in hot weather. In the winter the house is partly warmed by fireplaces, partly by hot water pipes.
5. The Chief Commissioner's study is arranged at the S.W. corner of the building, to which there is independent access. Native chiefs and others who wish to see him can thus do so without passing through any other part of the house.

The one improvement I should like to have seen was the provision of a proper sewage system. This proposal—to instal a cultivation tank—was negatived by the Government of India. The bath rooms might also with advantage have been placed in a lower storey. Under some of the rooms are cellars used for pantries, baggage rooms and for hot water apparatus.

The 5 principal bedrooms in the house are supplemented by 3 other suites in the guest house.

The park and garden add most materially to the dignity of the building.

As regards the architecture the experts supplied only the external elevation, and that had to be altered a good deal to make it suit the site. The cornice and pediment are I think worth noting.

The interior work was left to the local engineers. We consulted the Chairman of the Fine Arts Exhibition at the Delhi Durbar as to the treatment of some of the rooms in Oriental style and he suggested our employing the Mayo School of Art at Lahore. Accordingly that institution undertook a contract for the hall and the billiard room. The Chief Commissioner preferred that Capt. Rogers should work out his own design, subject to my approval, in the dining and drawing room. Interior Decoration.

The hall (*Plate* VII.) is certainly very beautiful. The wood carving of the great brackets that support the gallery, of the balustrade of that gallery and of the corner balcony is specially characteristic of Oriental art. Round the hall is a carved wooden dado with panels in which are painted poppies and irises alternately. Above this is a space for trophies of arms and of the chase. The room is lofty, 26′ high, and the rafters and joists of the roof are not concealed by a ceiling but simply painted. A stencilled border finishes the upper part of the wall surface. The fireplace is of Eastern design and inlaid with tiles from Multan.

The billiard room is somewhat similar. The skylight was a difficult constructive problem, as an ordinary lantern light would have been intolerably hot. Capt. Rogers managed very cleverly to give ample light without admitting any of the sun's rays.

The drawing room had its severe squareness relieved by two bow windows and by an anteroom or boudoir. These are separated from the main room by elliptical arches, panelled with Kashmîri walnut, the spandrels and panelling above being filled in with carving. The fireplace, from an English design, was built with glazed tiles surmounted by a mantel of walnut and teak. The ceiling is in wooden panels painted cream-white, and the walls are papered with a rich pattern of gold and lilac. The floor is a polished parqueterie of various Indian woods. The doors are of walnut with carved architraves.

The dining room is naturally plainer in its treatment. The floor is of teak laid on rails for dancing, the doors of walnut, and the mantels of walnut and teak with *repoussé* copper work from Kashmir inlaid.

The whole of the interior work of the house (except hall and billiard room) was carried out by a special staff of native workmen whom Capt. Rogers managed to collect. Patterns of the various parts were drawn out and roughly placed in position before a final decision was made. Thus it was possible to bring together master and workman in the old-fashioned way, a method of work which is much more interesting than merely supervising the ordered work of a contractor.

Design of Other Residences.

Passing on to consider the designs of the other residential buildings, I would first point out that considerations of rent imposed a limit on the capital cost. The rules of the Government of India in respect of public buildings erected for the accommodation of officers (military or civil) are :—(1) That a charge of $3\frac{1}{2}$ % per annum be made on the capital cost ; (2) that additional percentages in respect of annual and special repairs be estimated by the local engineers. These percentages in the case of good substantial buildings average 1 % and 0·75 %. Hence the total annual charge is about $5\frac{1}{4}$ % on the capital outlay. The maximum rents being fixed by the local government, the designs for the buildings were arranged so as to fall within the corresponding capitalised sums. The designs were of course varied to suit the varying pay of the officials concerned.

Provision of Officers' Quarters generally.

I may add that the subject of providing quarters for officers is not as a rule encouraged by the Government of India. The pay of officers in India includes provision for quarters, and they are supposed to make their own arrangements. This is usually done in cantonments by officers hiring bungalows built by native speculators under the control of the Cantonment Committee. But in many of the frontier cantonments native builders decline to risk their capital, and when they can be induced to do so their interest is—not unnaturally—so high that the result is most unsatisfactory. The increase in the garrisons of many of our frontier stations has made the demand for houses very great, and officers are often obliged to put up with most inferior accommodation. It was my earnest endeavour to induce Government to provide funds for officers' quarters, and I was so far partially successful that we were able to build some quarters (though not as many as required) for civil or military officers at Dera Ismail Khan, Bannu, Parachinar, Kohat, Peshawar, Cherat, Mardan, and Malakand.

In designing such buildings and using the flat mud roofs (4″ of earth overlying 2″ of tiles) common in Upper India, it is difficult to avoid bald ugliness. Unsuitable purposeless ornament is of course worse than useless.

I would, however, recommend any officer who may have similar designs to get out :—

(1) To study the external treatment in the buildings at the Aitchison College at Lahore. This college—for native chiefs—is the best example I know of modern work.

(2) To study the buildings at Fatehpur Sikri, near Agra, where the Emperor Akbar built houses for his sultanas. This affords a notable example of ancient domestic architecture.

(3) Then, as regards interior treatment, pay very special attention to the proper construction of doors, windows and fireplaces. Those in native-built houses are clumsy in construction and hideous in appearance.

Types of Buildings.

There seem to me to be two general styles which are adopted in Oriental architecture, as exemplified in the above buildings. One is a combination of octagonal pillars, either singly or in groups, surmounted by square low capitals, together with arabesques in balconies or railings, tiled verandah roofs, no parapets and no deep cornice. This style is conspicuous at Fatehpur Sikri. The other style has the pointed Saracenic arch, enclosed in a recessed rectangle, surmounted by a recessed panel. This is combined with a very deep cornice and with projecting balconies. In woodwork this forms a common and very beautiful method of treatment, but it is less easy to produce in brick or stone.

I give two examples of modern buildings on the above lines, (1) the residence built for the Revenue Commissioner (*Plate* VIII.) and (2) that for the C.R.E. (*Plates* IX. and XXIV.) both at Peshawar. The cost of the former was about Rs.30,000; and of the latter Rs.18,000, including servants, houses, stables, roads, etc.

Another style is that adopted for the quarters of the 2nd Secretary (*Plates* X. and XXV.). This building is a little smaller than the C.R.E.'s house, but with much the same accommodation.

The above are all double-storied houses, an arrangement which I think is healthier for hot climates than single-storied ones. Some people however prefer the single-storied bungalows, which are certainly more common.

A very good arrangement for a large single-storied bungalow is shown in that built for the Judicial Commissioner at Peshawar (*Plates* XI. and XXVI.). It is an improved edition of the Deputy Commissioner's bungalow at Kohat, the latter having a central dome over the octagon instead of a flat roof. A dome however does not admit of a fireplace for use in cold weather nor can it be used as a sleeping place in hot weather, so the flat roof is better. The house is a very comfortable one.

The parapet in this case is not of Oriental design. It was worked out by Capt. Rogers, and I think its effect together with the pillars and eaves boarding is pleasing. The cost of this building with servants' houses and stables, etc., was about Rs.30,000.

Plate XXVII. gives some examples of parapets and cornices.

The law courts (*Plate* XII.) were designed by the Government architect. The treatment of the site with terraces, stairs, and turfed slopes was no part of the original design, but I think it has added to its effect. This design was I think the sixth that was prepared; one of these was a purely Oriental one of (in my opinion) singular grace worked out by Capt. Rogers. However the consulting architect would not have it. The cost was about Rs.6,000=£4,400.

The plans of the Chief Commissioner's office (*Plate* XXVIII.) and the Administrative office (*Plates* XIII. and XXIX.) show somewhat similar arrangements, viz.:—a block with rooms for officers in front, connected by a passage or corridor with a large clerks' block in rear. The external treatment is almost the same—quite plain brickwork with a cornice and parapet sufficient to break the long horizontal sky line.

The C.R.E.'s house at Dera Ismail Khan (*Plate* XIV.) shows another form of treating a parapet.

The only other building which I propose to describe is the Chief Commissioner's summer residence at Nathia-gali. There, in the midst of pine forests where in winter the snow lies deep, a flat roof would be out of the question, and the rooms need not be so large nor so high as in the plains. The building was designed to suit the site—a little neck of land where a spur runs at right angles to a main ridge. In front of the house the site is sufficiently open to form lawns for tennis and croquet.

As regards the plan, a central passage leads straight through the house, with bedrooms opening off it on either side. At the end is the C.C.'s office arranged with separate access, so that anyone coming to see him on business can do so without intruding on the privacy of the main building (*Plate* XXX.).

The main walls are of limestone. The roof is a queen post truss with shingle covering. A lantern light over the passage gives an apex to the whole structure.

This building, finished early in 1904, with its stables, servants' houses, kitchen, guard-room, and grounds cost some Rs.30,000. I did not see it after it was complete but I believe it has given satisfaction.

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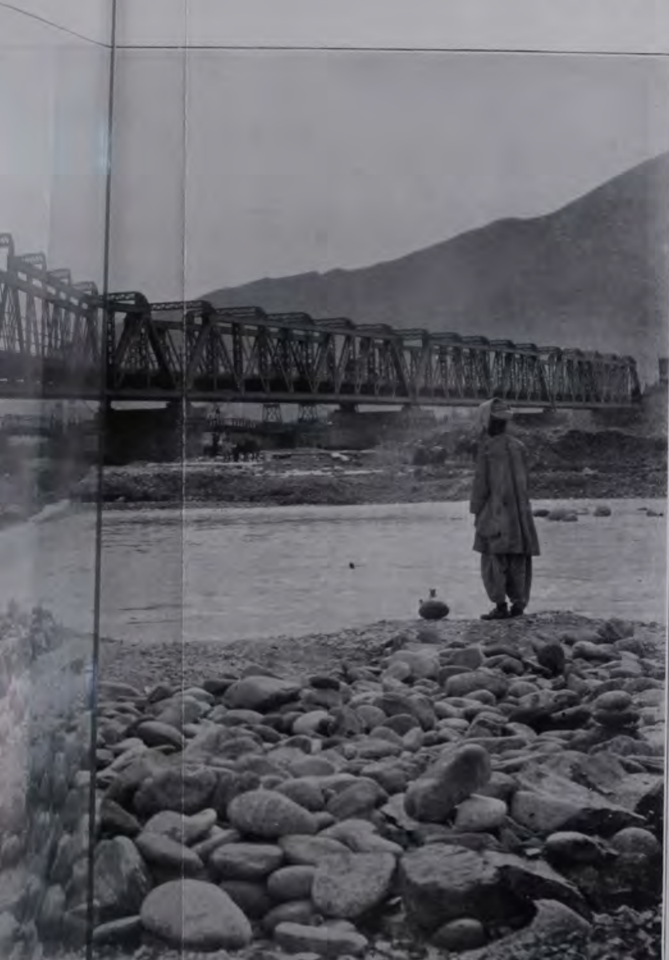

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C.R.E.'s Residence, Dera Ismail Khan.

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ARMOURED TRAINS.

BY

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CONTENTS.

ARMOURED TRAINS.

By Capt. H. O. Mance, D.S.O., R.E.

Prior to the South African War the lack of data based on actual experience rendered it only possible to consider the general subject of armoured trains tentatively; and even now, owing to the entirely different circumstances and surroundings in which campaigns may be fought, as compared with South African experience, it is only with caution that the application in future warfare of the general principles underlying the employment of armoured trains can be forecasted. In Egypt in 1882 an armoured train, constructed by Capt. Fisher, R.N., was of great use on the reconnaissance of August 5th. Two trucks were armoured with iron plates and sandbags and a Nordenfelt and two Gatling guns were mounted in them, and also a 9-pr. Other armoured trucks contained 200 bluejackets. A 40-pr. gun was also used with great effect from a truck protected by an iron mantlet. The locomotive was placed in the middle of the train and protected by slung sandbags and rails.

The subject may be divided into three main heads :—

I. The Uses of armoured trains, in which will be considered how the essential characteristics of armoured trains can be best turned to account.

II. The Construction, Equipment, and Garrisons of armoured trains, with a view to their undertaking the duties indicated in (1) with a maximum of efficiency.

III. The Organization and Administration of armoured trains and the many details involved in the same.

I. THE USES OF ARMOURED TRAINS.

Characteristics.

The particular characteristics of an armoured train (excluding of course heavy guns mounted on railway trucks) are as follows :—

(1). *Very great mobility* in certain definite directions only, and with limitations noted below. This mobility implies :—

(*a*). *Power to effect concentration* with rapidity, and the possibility therefore of employing every train where it will be of the greatest use.

(*b*). *Ability to reinforce* threatened points speedily.

(2). *Great strength* (except against guns) both for defence and offence within its radius of action.

(3). *Continuous availability* day and night; when the engine is being washed out or repaired another can be substituted if necessary.

(4). *Moral effect*, both as a support to co-operating forces and when making a sudden descent on the enemy.

(5). *Comparative freedom from surprise* owing to its always being in fighting formation ; also the advantages gained by a knowledge of the country at least as favourable as that of the enemy.

(6). *No trouble to ration.*

(7). *Liability to have communications interrupted*, and therefore to be isolated with comparative ease ; and also to be destroyed or seriously damaged by skilfully laid mines, etc.

In South Africa, however, the damage to armoured trains by mines was much less than might have been expected. The Boers rarely laid mines at bridges, or even at small culverts, possibly because they imagined the approaches were mined by us, or because they thought that their own mines were likely to be discovered. Thus, the garrisons of the trains, unless actually injured by the explosion, which at most affected one truck, stood a good chance of escaping unhurt, mere derailments not being very dangerous at the speeds employed. Three kinds of efficient mines were laid :—

Hostile Mines.

(*a*). *Contact mines*, which went off under the first truck. A truck of railway material was pushed ahead to explode any such.

(*b*). *Contact mines with delay action fuze*, so as to go off a few seconds after the release of the mechanism. The delay action fuze is liable to fail and thus render the mine useless. It is also purely a matter of chance whether the explosion occurs when any particular truck is over the mine ; however, they might do damage.

(*c*). *Observation mines* let off by a string pulled at the right moment. This was the most dangerous pattern in South Africa, but its employment was discontinued owing to the fact that the man pulling the string had not much chance of getting off. When such mines were expected maxim fire used to be opened on any likely cover for watchers before the train passed it. It will be seen that in no case is a mine in the open likely to render a train completely *hors de combat*. A mine on a bridge or sharp curve on a high bank might do so by wrecking the whole train. If the enemy takes to interfering with the line it is a good thing to mine the approaches to the larger bridges and culverts and spread reports that the whole line is mined; also to lay ambushes to meet expected raids. If mines are laid, precautions should be taken to protect one's own troops and friendlies.

(8). *Vulnerability to artillery fire.* Experience in South Africa points to the fact that it is not at all easy to hit an armoured train with artillery fire, especially if a well-directed fire is kept up from the guns of the armoured train. A single attacking gun, especially if not well placed, might be overwhelmed, before it had done much damage, by converging fire from two armoured trains. A Russian armoured train appears to have sallied out from Port Arthur and to have been subjected to artillery fire. It managed to return, however, so that the damage could not have been very severe.

(9). *Liability to railway accidents*, especially if the O.C. does not possess the necessary grounding in railway technical knowledge. Most of the armoured train casualties in South Africa were due to railway accidents not caused directly by the enemy.

(10). *The freedom of action* of armoured trains is affected by, and affects, the running of traffic on the railway. Armoured trains must give way to ordinary trains except for urgent military reasons, as otherwise the proper maintenance of traffic, which is one of the objects of armoured trains, would be impeded.

(11). *Expensive to run.* The cost of the engine and trucks, wages of enginemen and guard, coal and stores, must be reckoned with.

USES IN OPEN COUNTRY.

It is hardly likely that any other country will lend itself so extensively to armoured train operations as was the case in South Africa during the campaign of 1899–1902. The area of operations was enormous and the troops available for guarding the great length of the line of communications which had to be protected were small in number. The enemy were devoid of artillery during the greater part of the campaign, and an armoured train, if isolated, could hold Conditions in South Africa.

out against any force which could be brought to attack it. The enemy were also unenterprising in their attempts to wreck the trains, being disheartened either by complete lack of success or by the insignificant results which seemed to reward their somewhat hazardous raids. Those inhabitants who might have been hostile were removed. The quantity of traffic required to be run was limited, and even on the most important line night running could be dispensed with and the line kept clear for armoured train operations. The open nature of most of the country and the absence of deep cuttings and tunnels afforded a clear field of fire, and together with lower speeds reduced the chance of a railway accident to a minimum.

Duties under Similar Conditions.

Under these and similar circumstances armoured trains can be usefully employed for the following duties :—

(1). *Accompanying extended advance guard cavalry* to forces advancing astride a railway.

(2). *Drawing the fire of the enemy's guns.* This was only done in the earlier stages of the war in South Africa, when the armoured trains were not provided with guns and had to withdraw as soon as their object was effected, *e.g.*, Graspan and Magersfontein.

(3). *Escorting construction trains* at rail-head or when repairing damage to the line effected by the enemy. Later on each armoured train carried enough railway material to repair slight breaks in the railway or telegraph. In the case of breakdown trains, armoured trucks should be provided for the repairing party in case attacked *en route* to the break.

(4). *Patrolling* an otherwise undefended line. If an unguarded line is left to itself for most of the day and night the enemy are encouraged to destroy it frequently. The mere knowledge of an armoured train patrolling the section limits, or prevents, this. To avoid firing on our own patrols orders were issued to all concerned that, if an armoured train signalled to parties near the railway by a wide shot, they were at once to send a man to report and meanwhile were not to move further away from the line, otherwise they would be fired at. This worked very well.

(5). *Escorting Trains* either singly or in convoys of three or even four trains. Even if there are not enough troops to blockhouse the railway, it is possible to ensure a fairly constant and reliable service of trains in spite of the proximity of comparatively large bodies of the enemy, provided the traffic does not exceed three or four trains daily in each direction and the country is open. The general principle of the system employed is to provide each train with sufficient escort to hold out against an attack by any likely number of the enemy until relieved in the ordinary course.

In South Africa, where the trains rarely ran over 30 miles an hour, on the Mafeking railway, the line was divided into sections of 100 to 150 miles between the important garrisoned locomotive centres, these distances being a daylight run. All the trains for the day, not exceeding four, left these centres at daybreak for the next centre in either direction, escorted normally by one armoured train, which ran after the first train; also one armoured truck with a garrison of 10 men was attached to the rear of each of the last two trains. The trains of a convoy maintained an interval of 400 to 600 yards, with orders if attacked to close up unless otherwise ordered by O.C., Armoured Train, who was responsible for the defence of the convoy. The leading train pushed one or two loaded trucks before it if the existence of mines was suspected. Protection from bullets was provided for the drivers and guards on the more threatened sections. Additional single trains can be run independently if escort is available, or occasionally unescorted trains may be risked if the intelligence obtained is good and the line is not specially threatened. Troop trains were run unescorted, but some armoured trucks were attached for part of the troops to occupy as a *point d'appui* if attacked. If the enemy is reported in force within striking distances of the railway the escort must be strengthened by adding one or more armoured trucks or by running an extra armoured train behind the convoy. As all the trains and trucks employed on the above duty were of the open pattern without overhead cover, it was necessary to hold the few commanding points over the line by blockhouse posts, which also patrolled over unheld broken ground near the railway before the passage of the trains. (The above is only an outline of the scheme which worked very well on the section referred to).

(6). *Reinforcing isolated posts* or a line of blockhouses if attacked, or a small detachment operating near the railway, or a thin line of troops awaiting the enemy driven up to the railway by other troops as in the S. African "drives." In view of the very small garrisons employed, the armoured train was in itself stronger than all but the largest garrisons on the line of communication.

(7). *Lying in wait at night* at likely places in a line of blockhouses, or failing this with a line of outposts along the railway at wide intervals, so as to discover parties of the enemy trying to cross or damage the line, and either drive them back or force them to abandon their cattle, sheep, transport, etc. In this way, by making the act of crossing the railway a risky one, the free movement of parties of the enemy is undoubtedly hampered, and interruptions to the railway are reduced in proportion.

(8). *Escorting platelaying gangs* when individual gangers are sniped and the line has to be maintained by strong gangs working under escort.

(9). *Collecting information from gangers and others* and acting as moving telegraph and telephone offices and signal stations.

(10). *Escorting* special stores such as dynamite, ammunition, heavy guns, etc.

(11). *Escorting* prisoners, or superior officers on inspection duty when the trains are not otherwise employed.

At Mafeking also during the early stages of the siege an armoured train was employed with considerable effect. Owing to the level nature of the country an open pattern armoured truck, with armouring only 4 ft. 6 ins. high, could be employed over large districts and this could be improvised cheaply and quickly.

USES IN ENCLOSED COUNTRY.

Altered Conditions as compared with South Africa.

Circumstances which affect the utility of armoured trains favourably or adversely abound to a far greater extent than might be imagined from the above review of the subject; and as many of them are of a highly technical nature, a thorough railway as well as a military training is essential for due weight to be given to each factor of the situation. It is proposed for sake of an example to enquire into some of the considerations affecting the possible employment of armoured trains in a close country like England, as it is hoped in this way to bring some of the main principles to light.

The altered *military* considerations, as compared with South Africa, are :—

(*a*). The limited area of operations in the case of England itself, which might result in the line of communications being so short compared with the front occupied that it is unlikely to require special protection.

In such a case there would be little scope for the special advantages of armoured trains, as, except possibly for coast defence, their *rôle* is almost entirely on the lines of communications.

It is surprising that no mention has been made of armoured trains in Manchuria; but possibly, owing to the enormous front occupied by the opposing armies, the chances of the communications being effectively attacked by either side were so remote that it was not worth while withdrawing much-needed engines and rolling stock from traffic for armoured train work.

(*b*). In England also we should be operating in a friendly and densely populated country, where, however, agents of the enemy might be residing in guises difficult to detect among so many aliens.

(*c*). The country on the whole is very close and wooded so that as a rule the field of fire from the railway is limited. Tunnels, deep cuttings, hedges and fences bounding the railway must be considered. The latter cannot be levelled owing to the danger of cattle on the line (none of the English engines have cow-catchers).

(*d*). Owing to high banks and cuttings the pattern and armament of armoured trains would have to be modified. This point comes more properly under the heading of construction. The method of use is, however, affected directly and indirectly owing to the difficulty of improvising suitable armouring.

(*e*). The garrisons of posts will probably be larger than was the case in South Africa, so that an armoured train would not be of such relative importance as a reinforcement.

(*f*). The enemy may have guns. He will probably be enterprising in his attempts to damage the railway or wreck armoured trains.

(*g*). It may be our duty to attack armoured trains employed by the enemy on captured lines.

(*h*). The special feature arises of employing armoured trains on coast defence.

Among the *railway* considerations are :—

(*a*). Much more and much faster traffic under normal circumstances. The ordinary traffic of the country could doubtless be considerably cut down in the theatre of operations, but would only be replaced by military traffic.

(*b*). This and the speeds employed, even if considerably reduced, and the short distances visible along the line, would very greatly add to the risk of accidents in working armoured trains ; and would demand high technical qualifications from O.C.s and much stricter regulations for working.

(*c*). The quantity and elaborate nature of engineering works on the railway, the far heavier rail (about 100 lbs. per yard as compared with 60 lbs. in South Africa), and the numerous points and crossings, render it possible for the enemy to effect rapid damage to the line of a more serious nature than in South Africa.

(*d*). The complexity of the signals will necessitate the employment of a driver or a pilot driver who knows the section of the line on which the train happens to be, instead of the same driver sufficing everywhere.

(*e*). There would probably be less difficulty in arranging for the construction of armoured trains than was the case in S. Africa.

Duties under Enclosed Country Conditions.

From the above it is reasonable to anticipate the following uses for armoured trains or armoured trucks in a close country, the existence of a fairly long line of communications liable to attack being presupposed.

(1). *At favourable places for coast defence.* These places would have to be carefully ascertained in peace time, so that the General Staff can at once know whether it is any use employing armoured trains to resist a landing at any spot. It is probable that only the guns of the armoured trains could be brought into action in most cases, but the armoured trains might act as an escort to any larger guns mounted on trucks and employed for coast defence as suggested by Lieut.-Colonel Sir Percy Girouard, K.C.M.G., R.E., some years ago.

(2). *Acting as a support for the advanced guard cavalry* to a force advancing astride of a railway, and to draw fire from the enemy's artillery.

(3). *Effecting minor repairs to the railway*, escorting construction trains, special stores, as already mentioned, prisoners, and superior officers on inspection duty.

(4). *Patrolling* a line of railway, and the country for a certain distance on each side, by sending out scouts at different points and collecting information from all available sources.

(5). *Escorting*, in the manner already detailed, *one* or *two* trains if the country is not too close. Convoys of more than two trains will hardly ever be possible on account of the difficulty in seeing them from the armoured train and consequently of defending them. Armoured protection for the driver and guard and a small escort, the latter in an armoured truck or in an armoured guard's van with provision for flanking fire along the train, will often be necessary to defend otherwise helpless trains from molestation by small parties of the enemy or by lawless bands which might come into existence in time of war. Troops in trains are helpless against surprise unless at least part of them are in armoured trucks. This is more necessary in a close than in an open country.

(6). An armoured train would be valuable as a *support for a strong patrol* sent out swiftly from any point on the railway to act against parties of the enemy or roving bands of hooligans, and might possibly assist in the operations.

(7). An armoured train would be a useful *reinforcement to a weak line of troops* holding a railway, or to a post either before or after an attack at short notice. However, an enterprising enemy would probably cut the line badly on each side of such a post, and possibly lay special traps and ambushes for expected armoured trains; also, as stated above, the posts being larger an armoured train would not afford such a relatively large reinforcement as was the case in South Africa. Naturally armoured trains cannot reinforce troops posted over tunnels and such positions would have to be held in greater strength in consequence. It might here be suggested that in the altered conditions, certainly the maxims and possibly the guns as well should be provided with alternative portable or mobile mountings besides their fixed ones on the train; for, when reinforcing troops in a cutting the maxims and some of the rifles would have to be taken to the top of the cutting; also, if the enemy have guns, it would perhaps be necessary to employ the armament and garrison of the armoured train in the defences of the post reinforced, and not in the train; and finally, should the train be isolated by a superior force of the enemy it might be possible to abandon it and save the armament.

(8). As *movable telegraph and telephone offices* and signal stations.

It is evident that whereas armoured trains played a very prominent part in the defence of lines of communication in South Africa, and even materially assisted in some of the main operations, in campaigns in a civilised country their *rôle* would be more subordinate, though, if fully utilized for such duties as they are specially fitted for, they would release troops for more useful work elsewhere. Instances would possibly occur where, by seizing a favourable opportunity, the officer commanding an armoured train could inflict severe damage on the enemy; but at the same time a few disasters due to the enemy or railway accidents may be expected even in the most favourable circumstances. In any future campaign the value of armoured trains will probably lie somewhere between the two extreme cases which have been considered.

II. THE CONSTRUCTION, EQUIPMENT, AND GARRISONS OF ARMOURED TRAINS.

At the commencement of the South African campaign armoured trains consisted merely of a completely armoured engine and of two trucks with their sides and roof armoured with loopholed $\frac{1}{2}$-in. iron plates; no other accommodation was provided. The garrison was 25 to 30 strong, with two maxims. Having no guns and not being shell proof, the armoured trains had to retire immediately they came within range of the artillery possessed by the Boers. Later on, as a result of the lengthy and varied experience against Boers without guns, the component parts of a regular armoured train in S.A. were as follows (see *Plates* I. and III.):—

Composition in South African War.

(1). Engine and tender.
(2). Tank truck.
(3). Two armoured trucks, each fitted up for infantry garrison, maxim, and searchlight projector.
(4). Gun truck.
(5). Material truck.
(6). Accommodation for officers and servants.
(7). " " enginemen.
(8). " " telegraph instruments and operators.
(9). Searchlight truck for engine and dynamo and men in charge.
(10). Communications.

These will be considered in order.

In South Africa the armoured trains, even at the best of times, were more or less improvised and consequently separate trucks were often employed for officers, enginemen, telegraph and dynamo, thus making a very long train. In civilized countries, if armoured trains were designed in peace time, these might all be provided for in one long coach body, which could be armoured and used as a fighting truck by the details occupying it. Similarly a gun might be mounted in each of the maxim trucks, thereby reducing the number of trucks to three, besides the engine, tank if required, and material truck. A material truck might be placed at each end of the train to save shunting. The above arrangement reduces the amount of armouring required and may perhaps render protected communication along the train possible. Whether a 12-pr. gun would too seriously interfere with the infantry and maxim fire on the same truck would require to be tested by experiment. A 6-pr. gun so mounted caused no prohibitive inconvenience in South Africa.

The separation of the fighting parts of an armoured train by unarmoured trucks, for the close defence of which only a limited amount of flanking fire was provided, presented no serious disadvantages in an open country like South Africa, under conditions where an actual assault on an armoured train was never undertaken; but in a close country, with a daring civilised enemy, or in savage warfare, the contingency of an assault will have to be provided for. Obviously a more compactly designed train, armoured throughout as suggested above, and with adequate flanking fire, would be less vulnerable; but, in addition, attention would have to be directed to the advisability of introducing the use of obstacles, which may be of two classes:—(*a*) Portable obstacles to be employed a short distance from the train to stop a rush; (*b*) barbed wire or other screens, either permanently fixed on the train or arranged to let down when required, so as to prevent the enemy from crawling under or between trucks or (in the case of open pattern trucks) from climbing up the sides.

(1). ENGINE AND TENDER.

At the end of the war it was only considered necessary to armour the cab of the engine and a few of the more vulnerable parts such as the injector pipes, the boiler being bullet proof. It is preferable to armour the tender so as to give the train a small assured supply of water for manœuvring under fire; but this was often dispensed with, as any holes could be easily stopped by wood plugs kept in readiness if the bullet penetrated (which it usually failed to do if it struck the tender below the water level). If it came to the very worst the fires could be drawn after the armoured train had stopped in a good tactical position, where it could hold out for as long as necessary. The effect of modern rifle fire at close range on the boiler, engine, and tender might with advantage be experimented with as, in view of the possibility, under other conditions, of fire being opened at point blank range, it may be found necessary to armour the whole of the engine as in the early South African pattern.

The doors of the armoured cab should slide open or, failing this, open inwards. Doors opening outwards are liable to foul fixed structures—a most important point to guard against for all parts of the train. Also doors are often opened and made fast by drivers while running, in spite of orders, and those opening outwards cannot be closed in a hurry in the event of the enemy suddenly firing on a train. (A fireman was killed owing to this cause on an armoured train near Houtkraal in December, 1900. Had the driver also been hit a disaster would have resulted as there was only one set of enginemen on the train at the time).

A good noiseless engine with a large reserve of power should be chosen as it has to work under disadvantageous conditions of varying water and fuel, starting at short notice and with irregular and sometimes long periods between washouts. One spare engine for every five armoured trains should be available to facilitate repairs, washouts, etc. This can be employed on shunting in the meanwhile.

(2). TANK TRUCKS.

These are required where the locomotive water supply is not at frequent intervals. In S.A. two or even three were occasionally used. The tank is not usually armoured, nor is it necessarily a fixture on the train, as it is often convenient to shunt it off when empty and replace it by a full tank. It should have a flexible coupling with the tender; but in case of a difference of level between the floors of the tank truck and tender, each armoured train should carry a lift and force pump and sufficient hose to pump from the tank to the tender and even from a reservoir on the ground level to the tender. In waterless countries provision should be made for an adequate supply of suitable tank trucks from the commencement.

(3). MAXIM TRUCKS.

One of these is situated at each end of the train (except when there is a material truck). A maxim is mounted at one end of the truck in such a way as to give practically all-round fire. The remainder of the truck is loopholed for the infantry escort. Bogie trucks were usually employed on account of the increased accommodation. Provision should be made for an extra maxim, carried as a spare, to be brought into action, and armoured protection must be provided for a search-light projector close to and above the end maxim.

Maxim trucks and armoured trucks for infantry escorts may be broadly divided into two patterns;—the *closed pattern* with armoured roof, for use in hilly countries or where the train is liable to plunging fire (possibly also with armoured floor where high embankments are to be run over), and the *open pattern*, for use in open countries where sufficient cover is afforded by armouring 4 ft. 6 ins. to 5 ft. high.

The *closed pattern* truck in South Africa was invariably armoured with steel or iron plates, and being of elaborate construction required a large amount of skilled labour and could not be improvised. Provision was usually made for flanking fire. *Open pattern* trucks could be armoured with either plate, rails, shingle between corrugated iron or boards, Jarrah sleepers, etc.; the sides being low and not required to support a heavy roof, it is comparatively easy to improvise such trucks. For temporary purposes large iron plates laid across the sides of an open truck will give protection from plunging fire except for the maxim detachment.

Steel plate is undoubtedly the best material for armouring as there are no weak joints and the loopholes can be made smaller than with any other pattern armouring for the same field of fire; moreover plates are absolutely bullet proof up to the edges of the holes if $\frac{1}{2}$-in. steel or iron is used. Such loopholes can also have sliding doors to close them when not in use or to vary their size according to circumstances. In close countries the question of loopholes, both for the infantry and also for the gun and maxims, is of great importance, for the train may be attacked at point-blank range and by troops who are under cover themselves. In these circumstances, assuming equally good troops on both sides, the advantage lies with the side presenting the least vulnerable target; an armoured train with small steel loopholes would be more favourably situated than the attackers in this respect, and could therefore hold its own against a considerably larger body of opponents. The more open the country the greater the relative strength of an armoured train and the less important to have elaborate armouring or small loopholes.

Closed Pattern.

In plate armoured *closed pattern* trucks (*Plate* I.) the maxim is mounted in a barbette, armoured to a height of 3 ft. and situated at the end of the truck and cut off from the rest of the truck by transverse armoured plates provided with means of access to the barbette. (The maxim must have an efficient shield and a mounting capable of firing over the ends or sides of the truck). The side and end armouring of the barbette is again carried on from a height of 5 ft. to the roof of the truck, thus giving cover to the man working the search light which is fixed immediately over the maxim in this pattern truck. The projector is mounted on the roof and the head and shoulders of the man working it emerge through a manhole and are protected as far as possible by hinged plates. Side ports, about 15 ins. square, with sliding doors, are necessary in at least one of the two maxim trucks for the spare maxim. It should be possible for the O.C. to control the train both from the barbette and from the infantry part of the truck.

Open Pattern.

In the case of *open pattern* trucks in South Africa (*Plate* III.), the maxim was usually mounted *en barbette* firing over the top of the truck armouring, the tripod mounting being usually employed. In one case the maxim was mounted in a revolving turret, thus giving complete protection (*Fig.* 1, *Plate* II.). In all mountings a shield is absolutely necessary; the porthole is a death trap without one. If made locally the minimum thickness of steel for the shield should be $\frac{3}{8}$ in., better $\frac{1}{2}$ in. The holes or slots in the maxim brackets for attaching the shields were found to vary considerably in the numerous patterns met with, and as this may occur again a rubbing of the bracket should invariably be sent with any requisition for a shield. It might be possible to design for the maxim and firer an all-round shield, about 18 ins. deep, fixed to a strengthened maxim mounting somewhat in the way that the present shield is fixed, and turning with the maxim; this would give as good cover as an expensive turret. Weight could be reduced by using specially hardened steel, in which case possibly $\frac{1}{6}$ to $\frac{1}{7}$ of an inch would suffice.

A special reserve of water for the maxim must be provided and kept where it cannot be misappropriated.

As mentioned before extra mobile or portable mountings may be advisable under certain circumstances. The ordinary tripod mounting, as generally used in South Africa, is probably sufficiently portable for the purpose, but a light wheeled mounting with space for boxes of ammunition would be better.

Among other mountings used on armoured trains one may mention a mounting consisting of one leg and two hooks, the latter to engage on the sides of the truck. This was sometimes used for the type of closed armoured trucks described above. Maxims were raked up from all sources for use on armoured trains. On No. 11 armoured train, originally constructed at Buluwayo in 1899, there was a ·450 maxim firing black powder. The mounting consisted of a travelling body minus the wheels, supported at the right height above the floor of the truck. As may be imagined the axles were very much in the way until a more convenient mounting was substituted. This train was sometimes called the cuttle-fish on account of its habit of obscuring itself in its own smoke when attacked. Other maxims were supplied without mountings or with equally inconvenient ones for armoured train purposes, and special mountings had to be designed for them. In some cases maxims could slide on rails across the truck and fire over either side if required.

The chief point is to mount the maxim so as to have the largest possible field of fire and ample elevation and depression, and so that it can be expeditiously worked without the firer unnecessarily exposing himself. The question of elevation is particularly important in the case of portholes; in one case a maxim was fixed at such a height that it could not be aimed at an elevation over 600 yards. Major-General Sir E. Hutton has suggested that each maxim should have a universal joint to make it independent of the inclination of the truck. This would be an important improvement if it can be devised, especially in the case of a derailed truck. 10,000 rounds per maxim were carried (3,000 in belts) and 300 rounds per rifle; also a complete box of spare parts for each maxim.

Search Light. The search light in these open trucks is best mounted in a conning-tower built immediately behind the maxim and thus giving it some protection (*Plate* III.). The floor of this tower rests on the top of the armouring, 4 ft. 6 ins. to 5 ft. above the floor of the truck. The tower is armoured with plates 3 ft. high and is made about 6 ft. long and the width of the truck. It should be accessible both by a trap-door and by ladders outside. The projector and also all the means of controlling the train are placed in this conning-tower, which holds three or four people and should have a few small loopholes 6 ins. from the top of the armouring.

The infantry part of the truck is loopholed 3 ft. from the floor, for firing, sitting, or kneeling. Loopholes may be provided at the corners or ends for flanking fire, if not otherwise arranged for. These trucks are usually roofed in with a low wooden or canvas awning with flaps to let down in case of rain. They are healthier than closed trucks in warm dry climates. In all maxim and infantry trucks for use on armoured trains provision should be made for easy access to the truck; also for cooking, as this would have to be done on the train; and possibly it may be advisable to arrange a minimum of latrine accommodation, so that the garrison may have no excuse for leaving the train when they are likely to be required at a moment's notice. A 200-gallon tank for drinking water should be fixed in each truck. Infantry.

(4). GUN TRUCK.

The guns employed latterly on armoured trains in South Africa were the pompom, 3-pr., 6-pr., and 12-pr. Q.F. on cone mountings. There were also a few obsolete weapons which need not be considered.

An excellent description with drawings and photos of the arrangement of a 12-pr. Q.F. on a truck (*Plate* IV.) is given in the *Detailed History of the Railways in South Africa*, recently published by the R.E. Institute, and it is unnecessary to repeat it here. The main points are the necessity of blast-proof magazines if all-round fire is required; the provision of armoured protection for the crew against frontal, enfilade, and reverse fire, and if necessary plunging fire; the necessity for very firmly bolting down the pedestal and the mounting of the gun to the framework of the truck, and at the same time for distributing the shock all over the frame of the truck. Sufficient depression and elevation must be allowed for to meet every contingency.

The small guns were similarly mounted in short trucks but without blast-proof magazines (see *Plate* V.). The ammunition carried consisted of 200 rounds per 12-pr. (50 % shrapnel, 30 % common, and 20 % case), 300 rounds per 6-pr. and 3-pr., and 3,000 rounds per Pompom. The feasibility of hand-drawn mobile mountings for guns on armoured trains was not tried in South Africa.

(5). MATERIAL TRUCK.

The material truck, pushed in front of the train to explode contact mines and therefore known as the "spasms" truck, consisted in South Africa of an ordinary bogie truck containing a supply of railway and telegraph material and breakdown appliances for temporary and small repairs. A strong cow-catcher was fixed to each end of this truck and was the means of averting many accidents. The rails and sleepers may be arranged as armouring in the manner described below (page 74), thus giving more space and some extra protected accommodation which might be useful on occasion.

(6). OFFICERS' ACCOMMODATION.

There will always be two officers on a train; three would be necessary in the case of more elaborate trains in civilized warfare if a day and night service is to be maintained. Continued life on a moving train, without other exercise, subsisting largely on tinned food, long and very irregular hours, and tiring exposure when in front of the train in wet or cold weather, let alone periods of anxiety, make the life of an armoured train officer a hard one, as was proved by the nervous and physical breakdowns in the case of several officers so employed in the late war.

Being possible under the circumstances, a certain standard of comfort should be aimed at in regard to accommodation for officers on armoured trains (and for the men also for that matter) to minimise the disadvantages referred to and to increase indirectly the efficiency of the train. A small kitchen, with accommodation for one servant therein, should be arranged for; also facilities for having a bath on the train (either a shower bath or space for a portable bath); also latrine accommodation. No money should be wasted on ornament.

(7). ENGINEMEN'S ACCOMMODATION.

In order to ensure adequate rest for the men off duty, separate accommodation is advisable for the enginemen on the train. In South Africa there was the additional reason that the enginemen, being civilians, were better kept rather apart from the soldiers. Sometimes the enginemen were accommodated in the searchlight truck.

(8). TELEGRAPH ACCOMMODATION.

Telegraph instruments and operators should be next to the officers if possible. Each armoured train in South Africa was fitted with telegraph apparatus and telephone or phonopore or both. The telephones enabled communication to be held with blockhouses, and the phonopores with stations and sidings along the line which were usually fitted with them for railway purposes.

(9). SEARCH LIGHT AND DYNAMO.

The accommodation for this must be situated next to the engine, if steam from the boiler is used for the generator as was almost invariably the case in South Africa, the steam being taken from the dome of the locomotive boiler by a flexible pipe. The truck must be armoured to the same extent as the fighting trucks, and be provided with a few loopholes. The men working the dynamo and engine must be accommodated in the same compartment, as they may be called up at an instant's notice by bell signal from the O.C. For details of the searchlight equipment see *Detailed History of the Railways in the South African War*. A spare flexible steam pipe and a spare driving belt (where such are used) should be carried on each train.

(10). COMMUNICATIONS.

The question of means of communication between different parts of an armoured train may here be discussed.

In no armoured train in South Africa was it possible to move from one end of the train to the other along the train, nor was the need of this urgently felt, though doubtless it would be a great convenience. In most cases when the enemy were on one side of the line only there was safe communication on the protected side of the train. In trains with no protected communication between trucks, each truck, if necessary, had to do the best it could under the senior present. The train was directed from one end or another by the O.C., who could control the fire of the whole train at night by the use of his search light. The second officer usually went to the gun truck.

In a close country the advantage of through communication is much greater; but it is not easy to provide it, especially past the engine, tender, and tank. It might, however, be worth doing in elaborately constructed trains.

It is obviously vital that the armoured trains should be under perfect control of the O.C. from either of the maxim trucks. Too much importance cannot be attached to the means employed for this purpose. In the earlier days of armoured train working in South Africa O.C.s could not realize the risks they were running by not keeping all their means of communication and control in the acme of efficiency, and it usually took an accident or a narrow escape from one to quicken the perception of the novice.

The following means of communication from the maxim trucks to the driver should *all* be provided, and frequently tested to ensure efficient working :—Pull gong, operated by a bell wire ; lever fixed to engine whistle, operated by bell wire ; and electric bell, which should also be worked from the officers' truck if required. The electric bell is the most convenient for daily use, but being liable to get out of order cannot be relied on. When all else fails lamps or flags can be resorted to, but these means are very inferior and expose the signallers. A stout cord round the driver's arm will do in an emergency if the cord is not too long. It is better however for the O.C. to travel on the engine himself if communications cannot be relied on. The whistle has the advantage that the O.C. can hear for himself whether the right signal has been transmitted; it can also be employed with advantage to give orders to the whole train. In fixing pull wires allowance must be made for the compression of the buffers, and occasional points for disconnection must be provided to facilitate shunting. Electric bell communication to the searchlight truck is also necessary.

As regards electrical leads every truck should be wired separately with draw clips, or, failing this, terminals at each end of the truck. These terminals are joined to the adjacent truck by short lengths of flexible insulated wire, easily disconnected for shunting, or for repairs if inadvertently broken. The searchlight leads should be fixed on one side of the train and the electric bell leads on the other side. All trains should have the searchlight leads on the same side to facilitate any interchange of trucks. $\frac{7}{20}$ insulated cable was used for searchlight leads in South Africa and $\frac{3}{22}$ for electric bell leads.

As regards communication between trucks, telephones or speaking tubes were tried on a few trains but I cannot say with what success. Megaphones were unsuccessfully tried. Any simple method of transmitting a written order from one end of the train to the other would probably meet the case and be the most reliable.

Finally, the O.C. must be able to apply the automatic or vacuum brakes from his post in case of emergency, the usual guard's van lever being fixed at each of the points from which the train is to be controlled. In the event of any of the levers not being fixed, the emergency brake, after the manner of that described below in connection with improvised armoured trains, should be invariably arranged for. A sudden application of the brake is to be avoided if possible, as, *inter alia*, it is liable to throw unsuspecting enginemen against sharp corners of the engine, but a preliminary tap on the lever suffices to warn everyone on the train. The protection of the brake pipes may not be possible, and in any case accidents may happen which might result in the brake being put on. To enable the brakes to be taken off without exposing the garrison, the release valve wires are led into each occupied truck, to be pulled at a given signal which might be communicated by whistle. Every armoured train must be fitted to carry ordinary train lights, and will therefore require brackets on the maxim trucks at each end, suitable for fixing either head or tail and side lights. Escort armoured trucks must also all be fitted at each end with brackets for tail and side lights.

Cycle Trollies. Some of the armoured trains in South Africa were provided with light quadricycle trollies. These were carried on the tank, and were used for sending messages along the line when the telephonic communication was for any reason out of order, for conveying orders to all troops along a section of railway, and for other similar purposes. On account of the ease with which they are held up they are not of much use for patrolling. In close country they would be inadmissible, as the danger of using them on open lines would far outweigh any possible advantages to be gained.

Every train should carry complete signalling equipment to enable it to get in touch with any column if necessary, and to communicate with scouts sent out from the train or with a party sent out to direct the fire of the train on an unseen target. Signalling Equipment.

Two pair of field glasses and a telescope for the use of look-outs and gunners should be provided.

IMPROVISED ARMOURED TRUCKS.

A special feature of armoured trains and trucks in South Africa was the number of improvised patterns employed.

The advantages gained by being able to improvise armoured trucks are as follows :—

The number of armoured trucks kept in reserve for special purposes and to replace trucks during repair is reduced to a minimum, thus releasing a certain amount of badly needed rolling stock for general traffic purposes.

Armoured trucks cover a greater mileage in a given time than almost any other rolling stock and are subjected to more shunting. In consequence they require repair at comparatively shorter intervals. The maximum time an armoured truck need be withdrawn for repairs need not exceed the time taken to dismantle the armouring of one truck and with it fit up another ; hence the advantage of a pattern of truck rapidly armoured without skilled labour or special appliances. An enormous saving in expense is effected by the employment of an armouring consisting of materials locally available, especially if these materials are not damaged by being used as an armouring. Also it is not everywhere that a supply of steel or iron plate and the necessary workshops and skilled labour for making plated armoured trucks are available, and the *personnel* will in any case be probably too busy with other work ; so that, unless unskilled labour and locally available material can be used, armoured trucks may possibly be unattainable in the required numbers.

Various materials were used in South Africa for improvised armouring of trucks, amongst them being girders, mealie sacks filled with earth (or better gravel), 6 ins. of gravel or stones between walls of corrugated iron or planking, sleepers reinforced with iron plates of all sizes and shapes fixed on as best possible, and lastly rails and sleepers. Such armouring should be tested whenever possible, but not in front of the men, as even though they may not be proof against perpendicular shots at point-blank range they might be good enough for practical purposes.

Of the above types, two patterns were in frequent use:—(1) Trucks armoured like the blockhouses by means of 6 ins. of gravel between sheets of corrugated iron kept the requisite distance apart by wood frames. A large number of trucks armoured in this way were employed to carry escorts, as this was the only way of cheaply armouring short trucks. Loopholes were provided, consisting either of steel plates with a small opening in the middle or of apertures (preferably X-shaped in plan) lined with sheet iron or wood and surrounded with the gravel filling. It will be found that the gravel tends to shake together and leave vacant spaces both along the top of the armouring and under the loopholes. To guard against the danger of this, holes are left at the bottom of each loophole, through which fresh gravel can be introduced till any cavity is filled up, and additional stones should similarly be added along the top of the armouring. Care must be taken that the stones are actually put in and that earth (which is of course useless) is not used. In South Africa a militia officer is said to have placed some of his men in a neighbouring blockhouse and ordered a few volleys to be fired at it in order to give confidence by illustrating the protection afforded by this type of work; fortunately the occupants of the blockhouse took the precaution of lying down as the gravel had not yet been supplied to fill the frames.

Under certain circumstances rails and sleepers are ideal material for armouring trucks rapidly and cheaply. Two 10-in. jarrah wood sleepers side by side are bullet proof, as also is a 60-lb. rail. In the case of rails resting on each other, a bullet striking horizontally between two rails would probably splash through to a certain extent; but such an occurrence would be very rare, even in the case of hot fire, and any splinters of bullets entering the truck would not do much harm.

The bogie trucks of the Cape Government Railway were about 36 ft. long. Two patterns of improvised rail and sleeper armouring were employed for different purposes on the Cape system and more particularly on the Kimberley line.

Low Pattern Rail and Sleeper Armouring.

The low pattern armouring (*Plate* VIII.) merely protected the sides of the truck up to the height of their flaps, which was 2 ft. The special fittings consisted of 6 clips, a couple of dozen wood keys fitting the section of the rail, and twelve small wood wedges,—the whole costing 30s. in South Africa. With 12 rails and up to 37 sleepers a truck could be armoured (as shown on the drawing) in one hour with unskilled labour. These trucks are useful in flat open country for the protection of working parties sent out to repair a break in the line or even for the transport of troops over much sniped sections. Fittings were kept at most large stations, so that any truck could be fitted up if required for an emergency.

High Pattern Rail and Sleeper Armouring.

The high pattern armoured truck (*Plates* VI. and IX.) required a larger number of rails and sleepers, being armoured to a height of 4 ft. 9 ins. The special fittings consisted primarily of three frames made of old 45-lb. rails, with two bolts joining the two portions of each frame at a height of 3 ft. 3 ins. from the floor level when the frame was in position; in this way a continuous loophole was provided along the sides of the truck. In addition, 6 dozen wood keys, 4 short rails each about 3 ft. 6 ins. long, and 20 ft. of 9-in. by 3-in. deal with a few spikes and nails,—the frames and all costing about £7 for labour and material—were all that was required for each truck. *Fig.* 3 of *Plate* IX. illustrates what happens in time, if the inside wedges are left out. Unskilled labour alone is required; one gang of 16 'boys' can easily fit up a truck in one day. Loopholes are provided at the ends of the truck by means of the short rails mentioned above.

In neither of the above trucks are the rails and sleepers forming the armouring in any way damaged by being used in the armoured trucks.

Both these pattern trucks have one great advantage not hitherto alluded to, but which is nevertheless of great importance and would be the more so in a close country and against an enterprising enemy, viz., strength to resist the effects of a collision or derailment. This strength is obvious when the details of construction are considered. In none of the bad smashes in which this pattern truck participated was any of the garrison seriously injured, though neighbouring trucks not similarly strengthened have been completely telescoped (see *Fig.* 2, *Plate* II.). This fact gives great confidence to the garrison and is worth striving to attain in some way in every pattern of armoured truck. These trucks were roofed with a timber framework covered with canvas or a tarpaulin, and held a permanent garrison of at least 10 men, who lived in the truck. In South Africa neither the axle-boxes nor the brake pipes were protected.

EMERGENCY ARMOURED TRAINS.

An armoured train can be improvised by using an engine with armoured cab. Some engines will always be so equipped for use in dangerous sections; but if not, it does not take long to arrange fairly good protection if sufficient plate is available in convenient sizes, and two or more of the above high-pattern trucks can then be attached. The maxims are fixed with their tripod mountings raised to the correct height for firing over the top of the armouring, the continuous loophole round the maxim emplacement being filled up with short lengths of rails, and a shield provided for the maxim if possible. The following communications with the driver should also be provided, the fittings being kept in store.

Whistle.—The fittings required are a lever, the shape of which depends more or less on the type of the engine in use. In South Africa a lever of the shape shown in *Fig.* 4, *Plate* VIII., was employed. Stout cord and strong screw eyes are required and should be stocked beforehand. Flexible bell wire is better.

Gong.—A few gongs should be kept in store for the purpose. Bell wire or cord and screw eyes again form the means of operation.

Both the above can be fitted in a very short time.

An *Emergency Brake* can be arranged by fixing a rope round the metal fitting at the end of the flexible vacuum pipe at each end of the train and passing the other end of the rope over the front of the armouring to the interior of the truck, so that the pipe can be pulled off its socket by a heavy jerk. This simple contrivance saved several accidents in South Africa.

Accommodation for the officers and drivers can be provided in an unarmoured truck.

Ammunition, rations, coal, and water must be arranged for, a garrison detailed, and an officer with some previous armoured train experience appointed O.C.

Such a train (see *Plate* VII.) can be fitted up in a day and may be of the greatest use.

The advisability of making elaborate armoured trains in a war against a civilised power may be questioned. A highly equipped armoured train, though doubtless much more efficient and powerful than improvised armoured trains, takes a long time to make and is very expensive. These considerations would doubtless weigh in the tactical manœuvring of such a train and opportunities would be lost by the unwillingness to risk the train being cut off. On the other hand the more or less improvised armoured train, with a simply armoured gun truck containing a light 3-pr. or 6-pr. gun and spare mobile mountings or carriages for both maxims and the gun, would not be such a serious loss if isolated, especially if the armament was removed across country; and therefore the train would probably be handled in a bolder manner. It might pay to have a certain number of this latter type of trains for use in exposed sections where the country is level and the open pattern truck admissible, the more elaborate trains being as a rule employed in situations where temporary isolation does not mean the train being captured.

GARRISONS OF TRAINS.

The garrison of a fully equipped armoured train in South Africa was limited by the accommodation of the train, which it was undesirable to increase beyond the size described above owing to the resulting loss of mobility.

A typical garrison was as follows :—

Infantry	25 (including 2 signallers)
Gunners	4 to 6
R.E. Search light	2
" Telegraph	1
" General (1 or 2 carpenters, 1 fitter, 1 blacksmith) ...	3 or 4
Medical orderly	1
Engine-drivers	2
Firemen	2
Cleaners	1
Guard	1 (sometimes a trained soldier does the duties)
Officers	2
Total	43 to 47

Every man except the medical orderly was provided with a rifle.

One officer should, if possible, be of the same regiment as the infantry, and if the gun is larger than 6-pr. Q.F. the other officer should be a gunner. The R.E. tradesmen are invaluable in effecting minor repairs on the train and in improving its efficiency and the comfort of the men by such devices as may suggest themselves to the O.C.

The medical orderly is most important; he not only attends to minor injuries and ailments on the train, but renders first aid to any casualties along the railway, the armoured train being naturally first on the spot after or during an engagement or railway smash.

If a trained soldier is employed in lieu of the guard he must have passed all the usual railway examinations qualifying him for the post.

In a specially constructed train there would probably be room for an increased infantry garrison, in which case a third officer should be appointed.

Officer Commanding.—The qualities required for an O.C. Armoured Train vary somewhat under different conditions. In South Africa unbounded keenness, energy, and dash were required to ensure the best performance of the wearisome, unintermittent, and even monotonous duties which sometimes fell to the lot of an armoured train for a considerable period, when the lack of excitement was often a sign that the work was too well done for the enemy to risk attacking a train or post or even trying to damage the railway or cross the line with live-stock. In a campaign in a civilised country a less impulsive character would seem to be best, together with much higher technical knowledge *which it would be as well to arrange for* *in peace time.* In any case tact is an indispensable adjunct, as also is a sound constitution.

In South Africa the armoured train afforded great opportunities to junior officers for independent command, and as there was always the possibility of achieving distinction these posts were eagerly sought after. There are undoubtedly also pleasanter moments on an armoured train. The sensation in the conning-tower on the move is at least as exhilarating as a ride on a fast motor and the effect is heightened when travelling at night with the search light. The frequent changes of scene and occasional opportunities of sport afforded pleasant breaks in the spells of hard work, and there was always the certainty of being sent where most likely to have a finger in any scrap which might be impending near the railway.

III. THE ORGANIZATION AND ADMINISTRATION OF ARMOURED TRAINS.

COMMAND OF ARMOURED TRAINS.

The fighting efficiency and the movements of an armoured train are so bound up with the technical details of its administration, and the results of mistakes likely to be so disastrous, not only to the armoured trains themselves but for the whole line of communication (*e.g.*, if the line is blocked by an accident at a critical moment), that it is imperative that the sole command of the armoured trains collectively should be vested in the staff officer responsible for their administration and efficiency. The Director of Armoured Trains* should be attached to the staff of the Commander-in-Chief in the field or possibly under different organization of the G.O.C. Lines of Communication. As regards all railway technical matters he would be responsible to the Director of Railways and he would have to be a Railway expert. If the theatre of war is large, he may have to appoint assistants or Deputy Directors—also railway experts—responsible to him for the efficiency of armoured trains on definite sections of the railway and attached to the staffs of the local G.O.C.s.

The employment of armoured trains and defence of traffic on a length of railway traversing areas under different Commandants is liable to lead to mistakes unless controlled by an officer specially detailed for this duty over a definite railway district. This Deputy Director of Armoured Trains should frequently travel along the line to inspect armoured trains and trucks, and also personally command all important concentrations on his Section. Besides being responsible to the Director of Armoured Trains for the efficiency of all the armoured trains and trucks in his district and for the best use being made of them, he should keep the ledgers for the equipment of each train and the accounts for coal, etc. Under this system alone is it possible to use the forces available in the most advantageous way, to secure efficiency and uniformity, to effect rapid concentrations to take advantage of opportunities, to arrange for coaling, watering, repairs and alterations to armoured trains with the least disturbance to traffic, and to *avoid accidents*. An armoured train resembles a man-of-war in that inefficiency may lead, irrespective of any action on the part of an enemy, to its destruction by accidents; such, as

* Bt.-Major (now Bt.-Lieut.-Col.) H. C. Nanton, R.E., occupied this position in the South African War and was attached to the staff of the Commander-in-Chief with the title of "Assistant Director of Railways (Armoured Trains)."

mentioned before, led to at least half the casualties in the armoured trains in South Africa.

Officers commanding armoured trains should receive orders from the Deputy Directors only. They must have the greatest latitude and should know best how to deal with every emergency without waiting for orders. The senior officer commanding armoured trains should be empowered to take command in an emergency, telegraphing his action to the Deputy Director and stating where orders will find him.

DUTIES OF THE DIRECTOR OF ARMOURED TRAINS.

Under the system outlined above, in the case of a large theatre of operations, the Director of Armoured Trains would discharge the duties indicated below :—

(1). Control the distribution of armoured trains among the different sections, in accordance with the requirements of the Commander-in-Chief or the G.O.C. Lines of Communications as the case may be.

(2). Frame orders affecting the working and efficiency of armoured trains generally, decide on questions of equipment or personnel relating to all trains, and obtain the necessary authority for carrying out his decisions.

(3). Appoint officers to the command of trains.

(4). Ensure general uniformity, while allowing such flexibility as may be advisable to meet local circumstances.

(5). Keep any records and statistics required.

(6). Prepare despatches, keep a general control of the accounts and ordnance ledgers, issue Army Orders and cyphers.

(7). Inspect districts, and, finally,

(8). Take command of armoured trains engaged on any very important operations involving the employment of a large number of trains.

No attempt will be made in the following pages to discriminate between those matters which emanate from the Director of Armoured Trains and those which would be initiated by his deputies, as this is of minor importance.

RETURNS.

The following returns were rendered by O.C.s Armoured Trains in S. Africa :—

(1). A nightly "Clear the Line" wire at 6 p.m. direct to the Director of Armoured Trains and repeated to the Deputy Director of the Section. This wire notified the position of the armoured train (in cypher if considered advisable). The receipt of any of the Director of Armoured Train's circulars used to be acknowledged by O.C.s Armoured Trains on their next nightly wire.

(2). A weekly diary rendered by each O.C.A.T. to the Director of Armoured Trains through the Deputy Director. This diary, besides briefly detailing movements of the train, actions, casualties, etc., described any improvements being effected to the train and contained any suggestions or requests for improving its efficiency. The Deputy Director made any comments on the margin and notified any action already taken on the points raised.

(3). Weekly state of personnel and ammunition—wired direct to the Director and a copy sent to the Deputy.

(4). Monthly return on the form shown in Appendix I., sent direct to the Director and a copy sent to the Deputy. Full details of the train, armament, equipment, and garrison were set forth in this return.

(5). Monthly nominal roll—direct to the Director and copy to the Deputy.

(6). Periodically when called for—Photo of train, and any other information required to keep the history of the train up to date in the Director's office.

ORDNANCE STORES.

As a general rule in South Africa small ordnance stores were drawn direct from any Ordnance Depôt by the O.C.A.T., the voucher containing his signature being sent direct to the Deputy Director. More important stores were obtained through the Deputy Director or with his previous authority (except in cases of emergency).

Clothing was obtained through the O.C. of each man's unit, who (as a rule) authorized the O.C.A.T. to draw direct from the A.O.D., making the requisitions out on behalf of the O.C. of the unit, to whom the vouchers were sent by the A.O.D.

Stores consigned to one train should on no account be appropriated by another without the previous authority of the Deputy Director or the original consignee.

A separate ledger was kept for each train by the Deputy Director. Maxims had to be taken on charge with all their spare parts in detail; this was just as well, as it tended to ensure that all the parts were carefully checked.

ACCOUNTS.

All accounts for services in connection with the construction and equipment of armoured trains, wages of civilian enginemen, supply of coal, etc., must be certified by the Deputy Director. In South Africa the coal vouchers were certified monthly by the O.C.A.T. before being passed by the Deputy Director. A simpler system would be for the O.C. (or the other officer on the train) to sign for coal and stores on delivery, these receipts being sent to the Deputy Director in support of the account; but it was found to be almost impossible to get a receipt for the coal from a responsible person, so that the former system had to be resorted to.

GARRISONS.

The garrisons of armoured trains are provided by G.O.C.s of L. of C. Districts under orders from Headquarters. On joining the train they cease to be under the orders of the Commandant furnishing them. The strength of the garrison must be maintained by the regiment furnishing it. A new garrison must be thoroughly instructed in their duties, especially as regards the orders for look-outs. The rules of local Commandants as regards passes for the men must be complied with or other special arrangements made, as otherwise half the garrison may be in the guard-room when the train is ready to proceed after a few hours' stop at a strange place.

One or two picked men from the garrison should be trained to work each searchlight projector.

Seven days' rations, including fuel, should be kept on the train. The trucks must be kept quite clean, especially the tanks for drinking water. Kits must be arranged so as not to interfere with fighting. Each man must have a field dressing. Generally speaking the comfort of the men must be studied as far as circumstances permit.

The men must not be allowed to expose themselves unnecessarily while the train is in the least degree liable to be fired on. Whenever the armoured train is in motion, one officer must be in the leading truck, and the O.C. incurs very serious responsibility if this is not the case. When the train is at rest at stations one sentry is required to look after the train.

The O.C.A.T. should occasionally inspect the men's equipment on the train, and should make frequent inspections to see that everything is in its place and no liquor is concealed on the train.

ENGINEMEN.

Railway Loco. Supts. should be ordered to furnish enginemen on demand if required for armoured trains. They should be picked men, so as to save the engine as far as possible in the unfavourable conditions under which it is worked; this is very important. In South Africa some trains had to frequently change engines owing to breakdowns, thus withdrawing other engines from traffic, and as a rule the Loco. Supt. does not (if he can avoid it) give a good engine to replace one which has suffered on armoured train work. On the other hand in one case, with two sets of splendid enginemen, an engine lasted throughout the whole three years war on the same train with only one period of six weeks in the shop for renewal of tubes. The engine was always quite clean and ready to start at an instant's notice.

The enginemen, if civilians, should be enrolled in some volunteer corps, so as to make them amenable to military discipline. Enginemen must have their rifles and ammunition with them on their engines. They must keep the doors of their engine armouring closed if the enemy are near, or at least the one on the exposed side. In no case should a door be fastened back open with wire or in any way which would need an appreciable time to shut it. Enginemen always want to keep the doors open owing to the heat, and so that they can see better.

The engines of armoured trains should be periodically inspected by specially appointed men and their recommendations notified to Deputies.

A railway guard must be appointed to each train. In S.A., where the duties were fairly simple, soldiers who qualified by passing the usual railway exam. were appointed guards with 1s. per diem extra duty pay.

Deputy Directors must keep a record of any good services of the train garrisons under them for the information of the Director. With a view to suitable recognition (*pour encourager les autres*) they should bring to notice in the proper quarter any gallant action on the part of railway servants. I can remember at least four such cases of conspicuous gallantry on my own section.

TRAINING OF GARRISONS.

Maxim Guns.—The O.C.A.T. is held directly responsible that the maxim is in perfect adjustment and condition. The fusee spring should be tested daily and the maxim fired once a week (at least twenty shots in succession). Spare parts must be carefully overhauled and the man in charge tested as to his capability of using them in case of breakdown. Care must be taken that the belts are *properly* loaded, and arrangements made for reloading belts in the case of a prolonged engagement. The reserve supply of water for the maxim must be immediately available. At least three men per truck should be taught to work the maxim.

Rifle practice from the train may be allowed to the extent of 6 rounds per man per week under the following conditions :—

(1). Firing must be personally supervised by the O.C.A.T.

(2). All posts which might be alarmed must be warned.

(3). The inhabitants or their live-stock must not be endangered.

(4). There must be no delay to traffic.

Judging distance must be practiced by daylight and by search light. In S. Africa, when a train was detailed to patrol at night with the search light, without much prospect of encountering the enemy, buck shooting was occasionally allowed on sections far removed from large garrisons, on condition that all neighbouring posts were warned of the proposed firing. This practice often turned a drudgery into a sport and afforded excellent training in scouting, judging distance, and firing by search light, such as could not have been obtained in any other way. It also provided fresh meat for the train.

Gun Practice.—O.C.s should be authorised to fire on an average about 6 rounds per gun monthly as practice, and to train spare men to replace casualties in the gun detachment. Guns, ammunition, and detachments, not commanded by a Royal Artillery officer, should be periodically inspected by one.

The whole garrison should be frequently practiced in standing to arms at short notice by day and night, including getting the search light started.

In order to make sure that all escort armoured trucks are provided with ammunition, hand signal lamps, flags, order boards, etc., and to keep a check on the strengths of the garrisons which will otherwise gradually dwindle away from men going sick or other causes, returns should, at the request of the Deputy Director, be compiled at stated intervals (about once a month) by Railway Staff Officers, these returns giving the above information regarding each escort truck at their stations.

TELEGRAPHS, TELEPHONES, AND PHONOPORES.

A compact list of diagrams should be issued to each O.C. Armoured Train showing the positions of the wires to be used for telegraph, telephone, or phonopore on the various sections. Connection is made by means of a long bamboo rod, with a metal hook at the end, which is connected by a coil of insulated stranded wire to the instrument. The rod is easily hung on the correct wire by means of the hook. The telegraph or telephone should be hitched on whenever an armoured train stops, a man being detailed for this duty, and the connection should be maintained till the train moves off. All trains in a section should be ordered to come on if possible at certain fixed hours every day. Messages which cannot be sent direct to another train should be sent to the most central station, to be forwarded when next the train comes on the wire, and should be telegraphed direct if it is important to make sure of delivery.

In the Transvaal, certain telegraph transmitting stations were held responsible that each kept in touch with all armoured trains in its section, day and night, advising the next transmitting station at once if an armoured train left its section. In this way armoured trains could be communicated with or could send messages with practically no delay. The armoured trains had to help keep in touch.

Telegraphs, telephones, and phonopores are maintained by the Director of Army Telegraphs, who provides telegraphists as in the case of any other military telegraph station.

Each armoured train should carry a few telegraph stores for repairing small breaks, and at least half a mile of cable, as the first thing to do at a break is to get one telegraph wire through somehow.

A telegraph instrument hitched on between two stations is liable to disturb the working between the two stations, and usually necessitates the re-adjustment of the instruments to enable the signals to be read. Armoured trains should endeavour to minimise any inconvenience caused in this way.

Phonopores.—The phonopore has the advantage that it can be used on the same line and at the same time as telegraph working, except that speaking cannot be heard during the actual transmission of a Wheatstone message. When there is little or no telegraph work going on, conversation can be carried on for 150 miles. With a fair amount of telegraphic work, 50 miles can be worked.

A military buzzer makes it impossible to hear, and either the phonopore or the buzzer must cease working. For this reason columns coming in to the railway must be ordered not to use buzzers on the railway line, as the armoured trains can in such cases transmit any messages through their telegraph offices. In case of need it is well to remember that a buzzer can communicate with a phonopore and *vice versâ*; also a phonopore can communicate with an ordinary telephone; but the two instruments cannot call each other up. (However, by breaking in on a conversation one can generally manage to get through in time). It does not matter if the two phonopores or buzzers are on different wires on the same line of poles, as communication is attained nearly as well by induction. About 15 to 20 phonopores per 100 miles will be as many as can be worked without interfering with each other too much.

To ensure efficient working, a definite procedure is necessary. Each station has its own call on the phonopore buzzer, generally a letter of the alphabet in morse. The phonopore calls of the armoured trains in S. Africa were "A," "B," "C," for numbers 1, 2, 3, armoured trains respectively, and so on, but preceded in each case by the letter "I." This made a very distinctive set of calls. When desiring to call up a station, listen first on the receiver to ascertain whether anyone else is using the line. If not, call up the station you want on the phonopore buzzer at intervals till the station answers by repeating its own call. Then give your own call and place the receivers to your ears. After finishing the conversation return the receivers to their hooks. If, while you are talking, somebody else calls up without having previously listened to ascertain if the line is engaged, he should be warned off by a quick succession of dots on the buzzer, or answered and asked to keep off or whether his message is very urgent. If you find the wire engaged when you want to send a message which is urgent compared with the conversation being carried on, break in on the conversation and ask the others to come off the phone till you have passed the urgent message. At times there is a great rush on the phone; but if the above rules are understood, there should be no difficulty about getting the proper precedence for urgent military or train messages.

The maintenance of phonopores is troublesome, but extra attention is less trouble in the end. In order to keep the instruments in good working order, long-continued calls which use up the vibrator battery should be avoided; and persons not concerned in any conversation should be made to keep off, as if they listen it uses up the speaking battery, and run-down batteries are one of the most frequent sources of trouble. The instruments should be kept free from dust and rain. The adjustment of the buzzer will require frequent attention, and spare platinum contacts should be carried on each train. A fuse, or carbon lightning arrester, or both, should be fixed in the circuit, in addition to the small arrester usually fixed on the instrument. One spare phonopore for every 10 or 12 instruments should be kept to replace instruments under repair. On lines where there are few trains, armoured trains can often facilitate the proper maintenance of phonopores at posts by taking the linemen from station to station on their tours of inspection or repair. It should be hardly necessary to add that any defect must at once be reported to the lineman.

Special Arrangements.—On the occasion of a "drive" or a special concentration of armoured trains for any purpose, a system of phonopores may prove invaluable if suitably organised. The special measures required are—

(1). An orderly within hearing of each phonopore at posts or on stationary armoured trains, day and night, to prevent the slightest delay in attending to calls.

(2). The use of the phonopore to be strictly limited to urgent military and train messages.

(3). A continuous note on the buzzer to be a signal for all conversation on the phone to cease at once. This signal only to be used by the officer commanding all the armoured trains or, in the event of an extremely urgent message affecting military operations by armoured trains and officers commanding posts. When used, it is followed by the call of the person with whom communication is desired.

(4). All concerned should know where to find the O.C. Armoured Trains.

(5). The use of the military buzzer must be prohibited by stringent orders.

In the same way it can be arranged temporarily for telegraph messages from armoured trains to receive precedence over all other at the central office during important military operations on the railway. At the conclusion of the operations, when most of the armoured trains become telegraph offices for the columns, a big rush of work must be arranged for.

In all messages the O.C.s Armoured Trains should send the number of their train in words and not figures, as in the latter case mistakes can very easily occur.

PROTECTION OF TRAFFIC.

The simplest way to protect traffic along a railway is by a line ot posts not more than ½ mile apart, the nature of these posts depending on the strength and character of the enemy likely to attack the line. If of suitable strength, the daylight running, at least, of traffic should be perfectly safeguarded. Owing to the number of troops required the above method is not always feasible, and the problem more usually resolves itself into making the best possible arangement with the means at hand.

In open countries with limited traffic, some form of convoy system would probably form the principal feature, especially as its flexibility lends itself to adapting the defence of the traffic on the different sections of the line to the liability of attack on each section, thereby enabling the maximum value to be obtained from the troops available. The convoy system as employed in South Africa has already been outlined, and some of the details of working will be dealt with further on.

When posts at frequent intervals do not exist, and a regular convoy system is impracticable or not considered to be justified by the chances of attack, armoured trains can afford a very fair protection to traffic by patrolling over the sections allotted to them and convoying trains over the most threatened part of their beat. This method is of course much less reliable than a proper convoy system in that a great deal is left to chance, whereas in the latter system the traffic is, if necessary, limited to suit the escorts available.

Suspension of Night Running.

In South Africa on unguarded sections of the line, not usually liable to molestation by the enemy, the military situation occasionally rendered it advisable to take some slight precautions. On such occasions the first thing done was to obtain the authority of the G.O.C. of the District to suspend night running over the doubtful section of the railway as a temporary measure to lessen the chances of a smash up due to the operations of one or two men. When the risk becomes sufficiently small, night running should be resumed, subject to the right of Commandants of posts to detain a train if considered advisable with due regard to the contents of the train. On the other hand it may be necessary to attach a small escort—say one armoured truck—if small parties of the enemy are liable to be met, and eventually to start the convoy system if the District is sufficiently threatened.

Convoys and escorted trains should not run at night as a rule. In the case of blockhoused lines, trains were not invariably run at night; but when the enemy are fairly inactive, unimportant trains may be allowed to do so subject to the above right of Commandants. This also applies to trains timed to run in daylight but running late. Night running must of course be suspended on such sections as armoured trains are operating on. If daylight running only is allowed, when regulating the running hours of trains to suit the varying seasons of the year, due regard must be paid to the great trouble and slight disorganisation involved by an alteration to the time-table. When night running is unsafe, any trains which may have been benighted should stable only at garrisoned posts. Civilian drivers have been known to refuse to run at night when the enemy were believed to be in the vicinity; but I have never known a driver refuse to run a train through when it was considered important that it should go.

Intelligence.

It is evident that the convoy system, and much more so any less comprehensive system of protecting traffic, can only be consistently carried out when reliable intelligence can be obtained of the presence and movements of any bodies of the enemy within striking distance of the line. For this reason the closest touch should be maintained with the Intelligence Department. Armoured trains themselves can collect a good deal of information from posts along the line and from gangers, and should, whenever feasible, carry scouts to send out and gain touch with any parties of the enemy known to be approaching the railway. Any intelligence gained should be wired direct to the Intelligence Department, to Commandants of posts concerned, and to the Deputy Director. Every train should be provided with good maps.

Patrols and Night Watchmen.

In S. Africa before the railways were blockhoused, natives were employed to assist in giving warning of any attack on the line at night. This they were very well fitted to do, as their senses of sight and hearing were keener even than the Boers'. Two extra "boys" were attached to each ganger's length (5 miles). Their duty was to patrol the line at irregular hours at night and report at once any sign of the enemy tampering with the line. A permanent watchman was also posted night and day at all the larger bridges and culverts (down to 30 ft. span) or deviation points, etc., which were not guarded by the military. These natives were all provided with lamps and flags to warn trains if necessary.

When the blockhouses were installed, the patrolling had naturally to cease, though it was still desirable for railway reasons when trains ran by night, it being the custom for the ordinary gangs to patrol the line during storms in case of a washaway. During bad storms at night on blockhoused sections, traffic was suspended till daybreak. In any case the ordinary gangs examined their lengths twice daily, when not sniped, and would report anything unusual or any spoor of the enemy to the nearest post or armoured train.

Other Precautions.

Another means of obtaining early notice of the line being tampered with at night is to insist on the telegraph being tested hourly during the night between stations, any interruption or partial interruption to be immediately reported to the nearest armoured train if accessible.

Certain other precautions are also advisable :—All concerned on the railway should be warned not to talk about the movements of trains in the presence of strangers, or in fact of anyone except the actual railway staff who have to carry out the arrangements.

Arrange that no food stuffs, cash, or other stores useful to the enemy are left by the railway at ungarrisoned stations in the vicinity of the enemy. This is particularly necessary where every endeavour is being made to starve the enemy out.

On lines where the trains run at slow speeds, as was the case up the steep grades of the South African railways, each train should have one truck, with vacuum brake disconnected, behind the guard's van, to avoid the train being brought to a standstill by the enemy riding up behind and pulling off the brake pipe. This rear truck should be a low one, so as not to obscure the side lights of the van. The tail light must be hung on the rear truck.

DETAILS OF THE CONVOY SYSTEM.

If there is not sufficient escort to provide for a daily service under the convoy system, trains may have to be run on alternate days only. Mineral trains and empties may be allowed to run unescorted, if it is impossible to escort all trains and inexpedient to stop any traffic. Unescorted trains should run singly. With the convoy system there is a block nightly (or on alternate nights as the case may be) at the terminal stations of sections, and it is of course impossible to get off both convoys simultaneously in the morning. The convoy on the most threatened section should be sent off first. Extra sidings should be put in at the terminal and principal crossing stations. As the batch of trains in the convoy naturally takes longer to complete a journey than a single train—for instance, each train having to wait till all the others have watered—every possible delay is to be cut down. Various expedients help this. The first portion of each convoy should take the traffic to and from intermediate stations. The second portion should contain the passenger coaches. The load of all engines should be reduced slightly, so as to enable the trains to conform to the regulations as to distances by increasing the pace if necessary. Checks which will necessitate any train of a convoy stopping on a steep grade should be avoided whenever possible.

In the convoy system the train in front is responsible for not getting too far ahead of the train next following, and the train following is responsible for not getting dangerously near the train next in front. The train preceding the armoured train will be apt to run on too far ahead unless this practice is checked. In open country the regulation distance was 400 to 600 yards. If the trains do not keep in touch, the escort, being split up, is nearly useless instead of each part mutually supporting the rest. A train if left behind might be easily cut off by the enemy. In close country trains must travel closer together but move slowly, whereas in open country they can keep rather wider intervals and go faster. To avoid chance of accidents when halting, each train of a convoy must come to a standstill 100 yards clear of the preceding train. In South Africa on first starting the convoy system it was difficult to get the drivers to adhere closely to the distances laid down, but after a time the system worked very well and smoothly.

Orders for Look-Outs.

The look-outs on the armoured train and armoured trucks escorting a convoy have important duties to do, and their orders should be posted in a conspicuous place in every truck. Similar orders, so far as they apply to them, are issued to all enginemen and guards on the section. A copy of the orders issued on the Kimberley section in South Africa is given in Appendix II., to indicate the nature of the orders required. In connection with these orders, although an error on the safe side, it must gradually be impressed on the look-outs and guards that the red flag should not be shown to following trains unnecessarily. For example, the regulation interval is not so indispensable going up hill as down hill or on the level; and if a train is stopped on a steep incline, serious delay may be caused. With intelligent running the intervals between trains will be found to increase going down hill and decrease going up hill. When any train in a convoy slackens speed, in addition to the red flag being shown from the rear truck, the driver should blow his small whistle to attract the attention of the drivers following, who may be attending to their engines at the time and not see the flag.

The look-outs detailed to watch the line (*vide* Appendix II.) should also look out for spoor of the enemy. If the ballast appears disturbed, the look-out should keep his eyes open for spoor on either side of the line, as the enemy may have tried to obliterate the traces of their crossing. Men should be told off to specially study definite sections of the line, so as to be able to stop the armoured train before each bridge at night if required to do so, or to say whether any spoor is fresh or old.

The above points chiefly affect the railway technical side of the convoy system. The following notes are concerned more with the military precautions taken.

Military Precautions.

The armoured train is not to run first in a convoy and should follow, not pilot, any single train it may be escorting; if the armoured train is disabled by a mine, the whole convoy may be captured, and it is also easier for an armoured train to protect the convoy in the position indicated.

Sometimes in South Africa an armoured truck used to be pushed in front of a train. Drivers object to pushing trucks as their view is somewhat obscured and loss of power is caused. As a matter of fact, although apparently tactically a better position, there was the disadvantage (unless the train was closely following another one, when the truck might as well be attached behind the preceding train) that such trucks were unprovided with cow-catchers. Moreover it is just as well that the escort should not be in the most likely position to suffer from mines. Latterly, if two armoured trucks were attached to one train, one was placed immediately behind the engine and the other behind the van.

No special trains must be run by the traffic department without the consent of the Railway Staff Officer, as he has to see that escort is provided. One armoured truck is not much use against a determined attack.

If the line is specially threatened and an attack on a convoy is anticipated, all O.C.s Armoured Trains will be warned and the escorts correspondingly strengthened. If mines are expected, the leading train must push two or three loaded trucks before the engine in order to explode them. These trucks must not be so high as to obscure the view of the driver. Special care must be enjoined in carrying out the convoy regulations, trains must be kept well in hand going down inclines, and large culverts and bridges must be specially examined before the passage of trains, either by gangers or by the leading train, preferably the former.

The O.C.A.T. is responsible for doing everything possible with the means at his disposal to protect his convoy. If attacked, the alarm is given by a long blast on the bass whistle, repeated by all the trains. The O.C. must endeavour to see all his convoy safely to the next post in either direction, after which he may devote his whole attention to the enemy if desired. Under ordinary circumstances it is hardly worth while for the O.C. to delay the convoy in order to return and tackle a few snipers. If the line is pulled up on both sides when attacked, the convoy should close up in the best position for defence, and should hold out till relieved. If the line is found to be slightly damaged, it can be repaired by the armoured train with the help of the nearest ganger. If found badly damaged in front of the convoy, the O.C. should wire for the breakdown train, giving full particulars of the damage done; and should return with the convoy to the next garrisoned watering station, after which the armoured train can go back to the break if required.

A specimen set of orders for men in escort trucks, additional to the "Orders for Look-Outs" already alluded to, will be found in Appendix III.

The country may be of an open nature, but with crops high enough to conceal an enemy close to the line. Such crops must be razed for at least 1,000 yards to render the convoy system at all secure.

THE TACTICS OF ARMOURED TRAINS.

The tactics to be adopted by an armoured train in action cannot be laid down beforehand for all conditions any more than can be done in the case of other troops. It must be expected that if a train is attacked, it will be at one of the points on the line at which it can fight least advantageously. O.C.s Armoured Trains should take every opportunity, when patrolling the line, of becoming acquainted with the positions near the line which might be taken up by the enemy, by visiting such positions and noting their weak spots. It may be possible owing to curves on the line to enfilade such positions with searching fire if not at close range, or to bring converging fire on the position by dividing the train, or the gun and one maxim truck may be kept out of rifle range and the other maxim truck taken in to closer quarters. The armoured train must withdraw from artillery fire if the latter cannot be quickly overcome and kept down, unless vital considerations necessitate the train remaining and chancing the consequences, in which case the enemy's aim can be disconcerted somewhat by frequently changing the position of the train.

Communication should be maintained if possible with the next garrisoned post. This may be effected sometimes by using the engines of the convoy trains, each with an armoured truck from the convoy, these engines to patrol the line between the armoured train and the post. An officer should, if available, be sent with each engine.

Posts along the line are usually provided with rockets as well as telephones. An armoured train should at once proceed to the spot indicated on receiving a signal by either of the above methods.

When a party of Boers wished to cross a blockhouse line, fire was opened on the blockhouses from all points while the party was actually crossing the line. Under similar circumstances, armoured trains should remember to look for and fire on the party actually crossing.

When ambushing a section of the line with the assistance of a few infantry, the procedure in South Africa was to place sentries in pairs or groups of three at 400 to 600 yards interval along the railway, and detail an armoured train in support for every 3 to 8 miles. Each armoured train had a definite section which it was not allowed to leave under any pretence whatever. The arrangements for ensuring this are described later in connection with the notes on "Drives." The sentries may be either dropped from the armoured train or they may be made to march out so that the movements of the train may give no clue to the enemy as to the section ambushed. The sentries should be in position before it is quite dark. To deceive the enemy the train may pretend to drop sentries on sections which are to be left unambushed. The troops from convoy armoured trucks can be used for ambuscading duties at night if required, the O.C. Armoured

Train being responsible for their being attached to the convoy trains next morning. When standing on the main line on these or other similar occasions, at least two sentries should be posted from the armoured train; they will keep close to or on the train.

"DRIVES."

The officer commanding the armoured trains on the occasion of a big "drive" should be stationed near the telegraph, telephone, or phonopore, at a fixed central point and not on an armoured train. He can then receive information and transmit orders with a minimum of delay. He should be responsible for all the railway arrangements on the section of operations, and may possibly be told also to issue the necessary orders to the troops along the line, as they can only be moved by rail under his arrangements.

On being informed of a proposed "drive" and of any extra armoured trains temporarily detailed to his section, the following preliminary arrangements are necessary, secrecy being maintained as long as possible.

Assemble trucks of coal and engine stores at convenient sidings for armoured train engines to refill from without leaving their sections. Arrange also for all tanks for watering locos. to be kept full, and also for full tank trucks to be kept where required to save armoured trains coming into a depôt for water. The tanks at all posts will have to be filled up just before a "drive." As armoured trains carry one week's reserve rations, no special action is usually necessary in this connection.

Arrange for all the escort trucks of the section to be concentrated where most likely to be useful. The garrisons may be employed out of the trucks if necessary.

Arrange for sufficient mounted or cyclist orderlies for the use of the O.C. Armoured Trains if he is likely to have to communicate with other departments at his station.

See that blockhouses or posts all have rockets for calling up armoured trains quicker than by the usual signal of three shots in rapid succession passed all along the line.

Decide on the plan of action. It depends on the relative strengths of the railway lines and driving columns whether the *rôle* of the armoured trains is to effect the capture of the enemy or to drive them back on the columns. In the former case, the railway being the stronger line, all the trains would probably lie low so as to lure the enemy towards the line. In the latter case they would patrol with search lights flashing at intervals to give the impression of a large number of trains and bluff the enemy back on the columns. Care must be taken not to throw the light on the blockhouses.

The armoured trains will probably have to help distribute the parties for the intermediate posts between blockhouses, and perhaps ration the troops along the line, or even supervise the construction of pits for the intermediate posts. The main point about these pits is that the earth obtained from them is thrown at the end of each pit to protect the occupants from stray shots from the blockhouses. The pits should enable fire to be opened on the enemy whichever side of the line he may happen to be. The distance apart of the pits depends on the troops available; but should not as a rule exceed 200 yards, even if only four men are then available for each pit.

Arrange to cancel the ordinary train service as may be necessary. A certain amount of military traffic for the columns may have to be worked through specially. One or more good Railway Staff Officers should therefore be drafted to the section at the points where the columns are due to concentrate after the drive. The traffic on the section of operations is best worked by the officer commanding the armoured trains from his central post by telegraph or telephone orders on the "Train despatching" system, the ordinary system of working being for the time being suspended. As far as possible each train, including special trains of all sorts, should have a written order directly from the O.C. Armoured Trains. Failing this, his telephone orders should be written down by a responsible person and handed to the officer, if any, in charge of the train and to the driver and guard.

If it is necessary to run a special train on a single line during a drive, each armoured train should be told to allow the special train to pass it at that end of the section nearest the approaching train. The special train should run at fast speed over each section. In this way each section is covered by its armoured train all the while as it can dash out if necessary any time prior to the arrival of the special at the crossing station, leaving a man to explain matters and hold the train, or it can follow the special quickly as soon as it has passed.

Arrange for a reserve of gun and S.A. ammunition for the armoured trains, also for a spare armoured engine fitted with a flexible steam pipe for the searchlight engine. An extra officer or two should be detailed for the armoured trains, in case additional trains are improvised or to replace casualties.

When the drive is about to commence, combined orders should be issued to all the armoured trains. Until experience has been gained most of the following points would probably have to be included:—

Orders to Armoured Trains.

1. Allot to each train a definite section.

2. Each train to place a red light at each end of its section one hour before dusk, a man being left in charge to keep the lamp burning. In rare cases he may be allowed to conceal the light and only show it on the approach of a train.

3. Each train to place three railway fog signals 10 yards apart, 600 yards inside the red lamp at each end of its section. The train must keep between these sets of detonators.

4. O.C.s of trains would also have to understand that if the enemy try to cross the line at a particular point, the trains of adjoining sections may help with their search lights by illuminating the ground in front of the blockhouses of the section attacked, such illumination being effective for two or three miles. They must in any case look out for an attempted crossing in the section for which they are responsible, as the first attack may be a feint.

5. Trains must hook their phones on whenever they come to a stand, and should make a special point of doing so at certain notified hours.

6. Information *re* trucks of coal and engine stores; also water and rations if necessary. Before counting on coal or water, enquiries should be made as to whether they are still available. Economy of water is to be enforced everywhere.

7. During the day, in the absence of special instructions, armoured trains should carry out any rationing, etc., for troops at intermediate posts.

8. All intelligence to be at once wired or phoned to the O.C. Armoured Trains at a notified central point.

9. An officer to be always on duty in each armoured train. As far as possible he should remain within hearing of the phonopore when the train is standing.

10. Warn armoured trains of the position of any posts away from the railway but within range.

11. For special arrangements as to telegraph and phonopore working see the section on telegraphs, etc.

Very few orders are necessary for the troops along the line:— Orders to Posts.

(*a*). Each post must remain in its trench till relieved, one man if necessary being sent for rations and water to the nearest post provided with them.

(*b*). It is vital to economise water. N.C.O.s in charge of posts are held responsible that any water intended for the columns or armoured trains is not tampered with.

(*c*). The alarm is to be passed along the line by a prearranged signal, such as three shots in rapid succession; at night the post attacked must also fire a rocket.

Several points have also to be considered with reference to the arrangements immediately after the conclusion of the "drive." Surplus armoured trains will usually be sent out of the way to watering stations, leaving their telegraph offices, if necessary, where most needed.

Prisoners must be collected from the columns and brought in under the escort of an armoured train, and steps taken to ensure the proper people being ready to take them over on arrival.

All the extra men between posts must be brought in early to central stations to save water. The line of posts will also probably require water and rations, especially the former.

Arrange to collect the sick, etc., from the columns.

Finally cancel the special arrangements for the working of the telegraph and telephone and also the restrictions on traffic. The block you have caused by your operations will probably have more or less disorganised traffic and the supply of rolling stock for hundreds of miles.

TRAFFIC ARRANGEMENTS.

In most parts of S. Africa the telegraph stations on the single line of railway are a considerable distance apart, and the traffic is worked under a somewhat elaborate system by which trains are arranged to cross each other at intermediate sidings between telegraph stations. In some cases there are as many as three of these intermediate sidings, and the crossing arrangements are liable to become somewhat complicated. Trains are also allowed to follow each other, if necessary, at 20 minutes interval. The authority for a train to proceed is a written order duly signed by the station master at a railway telegraph station. This order carries the train to the next telegraph station, unless other trains are to be crossed, when the order only holds good as far as the first place where a crossing is to take place, a fresh authority being obtained from the train coming in the opposite direction. To avoid accidents these crossing arrangements must be rigidly framed and observed, and this involves a definite knowledge of the movements of all trains concerned some time in advance of their happening. With armoured trains such foreknowledge is not to be counted on, and it must be carefully considered, as regards each section of the railway, whether any special traffic arrangements facilitating armoured train movements are admissible without running undue risk of accidents.

It will in all cases be found practicable to allow armoured trains to work "Station to station" and not on a prearranged time-table, thereby insuring freedom of action and secrecy. This only meant in S.A. that drivers and guards were not to expect to be notified of any crossing of an armoured train until they saw it on their train order.

Arrangements can also be made for facilitating the "blocking" of a section while an armoured train is in it, in which case the armoured train can move as it likes while it is in the section. In a close country like England, with comparatively high speed traffic, the "absolute block" system must be adhered to, though this would not be much disadvantage owing to the double line being available in nearly all cases, and also because there are practically no intermediate sidings and the distance between telegraph stations is so short. In flat and very open sections, where the view usually extends for a considerable distance along the line, thus giving an additional safeguard, the arrangements shown in Appendix IV. were adopted in South Africa as a result of long enquiry and experience. The regular traffic in this case was carried out in daylight only, and usually ran in convoys, so that the conditions were very favourable. Such arrangements would only be applied in a close country at great risk. It would be preferable in the latter case to increase the number of railway telegraph stations during extensive armoured train operations. In some parts of S. Africa arrangements were made that an armoured train might closely precede any train, travelling in virtue of the order carried by that train.

Ordinary head and tail lights will always be displayed by armoured trains, except in sections blocked and in possession of an armoured train for patrolling, when the O.C. can please himself.

Each O.C.A.T. must be in possession of a copy of the railway traffic regulations, and must understand and obey them except in cases of grave emergency, when the O.C. is held personally responsible for the results of any action taken. If any railway traffic regulations are broken owing to exceptional circumstances, an early telegraphic report must be sent by the O.C.A.T. to his Deputy Director of Armoured Trains. Should a train in action or otherwise have to back against its "line clear" order, it should blow its bass whistle, and at night display its search light and in any other way warn possible following trains. Armoured trains must not, without very special reason, delay ordinary trains. It is better, however, to delay a train than to run risks of accidents. Complaints by the railway authorities as to the infringements of railway regulations by armoured trains should always quote the number of the train and be sent by wire, so that the circumstances can be investigated while the matter is fresh.

Tact must be employed in all dealings with the railway officials and servants, and it must be remembered that it will take time for them to get accustomed to the special conditions attending military operations.

During special working the "distant" signals may in some cases be converted to "stop" signals, if necessary to facilitate station work and give additional protection to trains standing in a station.

Engines of armoured trains should be washed out at least every ten days. A good rule is to wash out on the first chance after the sixth day; and if the engine is not washed out by the twelfth day owing to the exigencies of the service, a telegram should be sent to the Deputy Director with a view to special arrangements being made if possible for relieving the engine. Engines and civilian enginemen on armoured trains are of course independent of any Loco. section. Repairs must be undertaken in any shed or shop on the written demand of the O.C.A.T., which may support the account passed for the service through the usual channel.

When the line is blocked for armoured train operations, no armoured truck or part of an armoured train is to be left on the main line for any purpose, unless protected by fog signals placed on the line 100 yards away each on side of it. Great care must be exercised in coupling up such trucks again, especially at night.

Military Orders Interfering with Railway Arrangements.

The effect of military orders on railway working must always be borne in mind and given due weight before issuing such orders.

For instance, suppose a train has to run over 500 miles of railway, the first 100 miles of which is threatened by the enemy. It might be considered necessary to attach an armoured truck to the train as escort. Such armoured truck would naturally not go further than the 100 miles and would then be hitched on to some train coming the other way. The result is that the train has to go the remaining 400 miles each way one truck short of its full load, thus causing a serious loss of carrying power. The least that can be done in such a case is to arrange for the armoured truck to be the smallest and lightest pattern available, so as to reduce as little as possible the useful load of the train.

Again, it might be considered necessary to keep open day and night a railway telegraph station usually closed during the night. When deciding how long to continue the arrangement it must be remembered that this involves the expense of extra staff. In the same way, if trains are ordered to be escorted by an armoured train, arrangements should be made for the armoured train to meet them in plenty of time to avoid delay.

MISCELLANEOUS.

Painting Armoured Trains.

Armoured trains should be painted to match, as far as possible, the prevailing colour of the country they are operating in. In one case in S. Africa, where a train was operating in bushveldt, the use of branches to hide the outline of the train when lying in ambush proved very effective. Disguising an armoured train as an ordinary goods train by means of tarpaulins, etc., might succeed in special cases.

Armoured trains should be numbered and known by their numbers as they are less confusing than names. All the railway truck numbers on the vehicles of every armoured train should be repainted in their proper places whenever the truck receives a fresh coat of paint. In this way unnecessary confusion in the rolling stock records is avoided.

Signals.

Uniform signals from the leading truck to the engine should be adopted for all armoured trains. The following signals are recommended, though they were not the ones adopted in most cases in South Africa :—

Stop	1 beat.
Forward (*i.e.*, engine to go chimney first)... ...	2 beats.
Back	3 beats.
Slower—Caution	4 beats.
Faster	5 beats.

The advantage of having only 1 beat for "Stop" is that, if the arrangements should go wrong, or the cord break at the first beat or owing to the train dividing, safety is more likely to be attained by the driver stopping than if 1 beat is a preparatory signal. Four beats is usually given before the 1 beat for "Stop." If the latter comes without warning it should be treated as an urgent signal.

Each armoured train should have half-a-dozen signal rockets, one to be sent up if engaged, two if assistance is required. Before search lights were provided, some of the armoured trains used to carry magnesium rockets for illuminating the ground if the presence of the enemy was suspected. If such rockets are employed, all concerned should be notified that they do not necessarily mean that the train is engaged. Rockets.

A local cypher should be employed by armoured trains for their nightly wires or other communications not with other departments. Each train must also have the Army cypher to communicate with the Intelligence Department, Staff, Columns, and Posts. Cypher.

Careless use of the cypher must be guarded against. The name of the place in the nightly wire of armoured trains should, if sent in cypher, be included in a message of several words, and not sent singly. With a simple cypher as used in South Africa the key is given away by a message like TRRNQ KLDRW LZZZZ sent from Deelfontein, especially if the office stamp of that station appears conspicuously on the message! In such a case it would be as well to mis-spell the name slightly or wire in cypher that the position is, say, five miles north of the station where the message was handed in. The "Playfair" cypher, or any other cypher in which the letters are cyphered in pairs, is much more reliable, but takes a long time and requires great care in its use.

Orders must be issued to all concerned that no improvised armoured train may be placed on the line except after previous reference to the Deputy Director of Armoured Trains. Unauthorized Armoured Trains.

Stores of material for repairing the railway and telegraph, including timber for temporary railway bridges, must be kept ready at suitable centres, and efficient arrangements made for rapidly assembling a construction train. If damage to the line is imminent, the material may have to be kept loaded up in trucks; and if frequent, regular permanent construction trains will have to be fitted up. Line Repair Materials.

APPENDIX I.

ARMOURED TRAINS, RETURN FOR THE MONTH OF.................................190...

No. of Train.	Armament.	Ammunition.	Garrison.	Truck and Engine Numbers and Description of Train.	Remarks.
		...........Total S.A.A. on Train.	Gun Detachment.		2nd in Command,
		...........per gun.	R.E. ,,		
		.. ..per rifle.	Infantry Escort.		....
		...........Shrapnel Complete.	Telegraphist.		.... Regt.
		....Common ,,	Lineman.		
		...........Case shot ,,	Signallers.		
			Electricians.		
			Med. Ord.		
			} Enginemen.		Section on which working.
	Search Light.				
	Phonopore.		Guard.		
	Sounder.		} Details.		
	Vibrator.			Engine Class.	

....

...................................*190...*

....

....*Regt.*

Commanding No.............Armoured Train.

N.B.—The original of this Form was foolscap size.

APPENDIX II.

ORDERS FOR LOOK-OUTS ON ARMOURED TRAINS AND TRUCKS.

(To be communicated to the look-outs by Officer or N.C.O. in charge, and copy hung in each armoured truck.)

1. Each truck is to be provided with 1 hand signalling lamp, 1 red flag, and 1 green flag. The lamp to be always kept lighted when the truck is on the main line after dark. FLAGS AND LAMPS.

2. Two look-outs to be on duty in each truck whenever it is in motion. In leading truck one man is to be told off exclusively to watch for obstructions on the line and warn the driver as may be necessary. He is to be stationed at the front end of the truck and will give warning on the driver's side of the train. The other look-out should watch for the enemy. He is to be stationed on the fireman's side of the train. LOOK-OUTS ON DUTY.

3. Except when the train is between station signals, the look-out of a truck pushed in front of the engine is responsible for giving the driver notice of any obstructions on the line as if the driver was unable to see anything. RESPONSIBILITY OF LOOK-OUTS.

4. When the driver is required to slacken speed or proceed with caution owing to cattle, etc., on the line, or the train being too close to the train in front, or on approaching a station, or from any other cause, a green flag must be shown by the sentry or the caution signal (4 pulls) given on the bell or whistle or other means of communication. CAUTION SIGNAL.

5. The stop signal on the bell or whistle (1 stroke) is to be given and red flag shown at once if the points are set the wrong way, or the line is damaged in any way or culvert blown up, or if there should be any obstruction on the line such as live stock, stones, or trolley, or if troops should be crossing the line in front, or if a red flag is shown from a train in front. STOP SIGNAL.

6. A red or green light is to be shown at night instead of the flag. Lamp or flag signals to be shown on the driver's side, but in cases of urgency the other sentry should also endeavour to attract the attention of the fireman. SIGNALS.

7. The driver is responsible for having head and tail lamps on the armoured train. These must be lighted at dusk unless O.C. gives orders to the contrary. The sentry is responsible for seeing that these lights are kept burning when in use. TAIL LIGHTS.

8. When escorting trains look-outs should call the attention of the Officer or N.C.O. in charge of their truck, when the armoured train is getting too far ahead of the following train or if the trains behind are separating too much. On the level the interval should be 400 to 600 yards and should not at any time exceed 1,000 yards, except at night, when the trains should run at intervals of a mile unless the enemy is expected when they should all go at the usual interval but very much slower. DISTANCES WHEN ESCORTING TRAINS.

REAR TRUCK. 9. In the rear truck one of the look-outs should be detailed specially to watch following trains. He should show a red flag or lamp, in addition to the fixed red light on the rear of the train, to a following train when his train commences to slacken speed, or is going to stop, or wishes the interval to be increased between itself and the next train for any reason.

If waved it is a signal for the following train or trains to go back. But the rear train must be the first train to go back, and the intervals between the trains must be allowed to increase, and on no account must the armoured train start setting back until the interval between it and the next train is at least 600 yards. Care must be taken not to wave the lamp or flag unless the following train is required to set back.

A green flag or light is a signal for the following trains to come on.

These signals should be passed back from train to train.

APPENDIX III.

ORDERS FOR TROOPS FORMING GARRISONS OF ARMOURED TRUCKS ATTACHED TO TRAINS.

1. The troops in armoured trucks attached to trains are under the command of O.C. Armoured Train, if there is one escorting the train. If no armoured train forms part of the escort, the troops in the armoured truck take orders in case of attack from the senior officer on the train.

2. Two men are to be posted as look-outs and relieved hourly throughout the journey. The rest of the men are to be ready to stand to arms at any time. Whenever anything suspicious is reported the whole garrison is to stand to arms.

3. To avoid firing on our own patrols or on inhabitants, troops in armoured trucks commanded by a N.C.O. should not, except in very special cases, open fire, unless fired on or unless the armoured train or some other part of the escort commanded by an officer opens a heavy fire. It must be remembered that occasionally a shot or two is fired from the armoured train as a signal to our patrols to send a man to the train. Such shots must not be taken as a signal to open fire.

4. When attacked, if the train is brought to a stand owing to the line being cut or the vacuum brake pipe being hit, the garrison of the armoured truck is to hold out until relieved, taking special care to economise ammunition so as to prolong their resistance. A man in an armoured truck is at a great advantage compared with a Boer in the open, and an armoured truck should be held against greatly superior numbers.

5. On no account are men to sit on the edge of the truck. They must not expose themselves at any time more than they do when standing on the floor of the truck.

APPENDIX IV.

ORDERS FOR ARMOURED TRAINS CROSSING ORDINARY TRAINS.

Except in case of emergency, armoured trains patrolling in any section must be at telegraph stations in time to avoid delay to ordinary trains, unless previous arrangements have been made on the telegraph instrument or phonopore with Station Masters at telegraph stations each side, and clearly acknowledged by them, or unless such arrangements are noted on the Order held by the driver of the armoured train. All such arrangements made by the train whilst in the section should be made on the telegraph instrument whenever possible in preference to the phonopore, as a record is then kept of the messages passed.

No ordinary train will be allowed to leave the telegraph station on either side until the armoured train in the section has notified its arrival on the siding where it will cross the ordinary train, or has notified the Station Master concerned that operations have been completed and that it is about to start for the siding where a crossing has been arranged. In the event of a failure of the instrument and phonopore on an armoured train, the latter will faithfully carry out any arrangements made; and failing such arrangements, will come to the nearest telegraph station to cross trains or to make arrangements. O.C.s Armoured Trains will be careful to notify Station Masters when they have arrived at sidings where they have arranged to cross trains, or, if delay is thereby saved, when they have finished their operations and are about to start for the crossing place.

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Closed Pattern Armoured Train.

PLATE II.

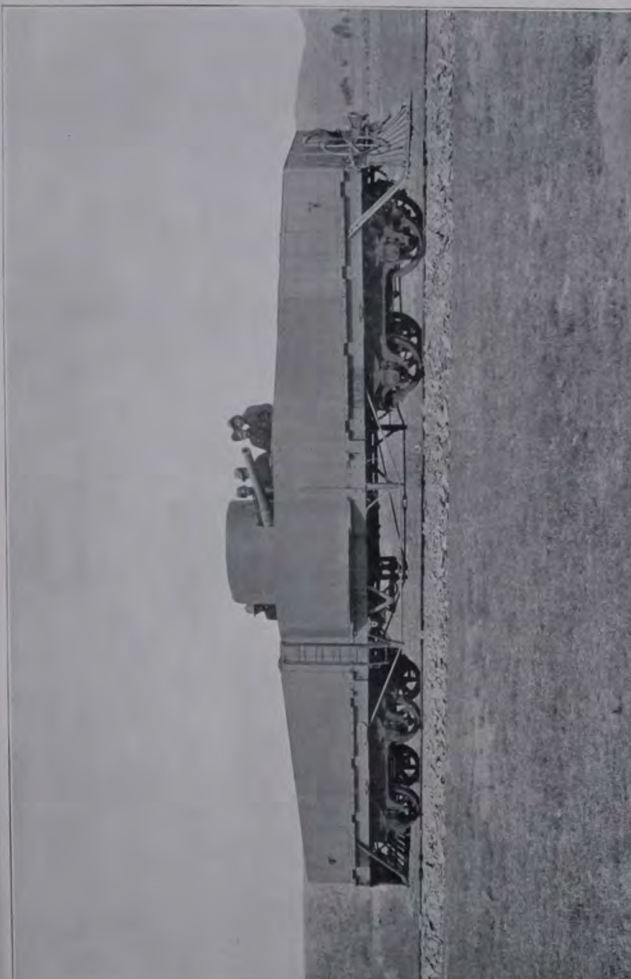
FIG. 1.—Open Pattern Plate-armoured Truck with Maxim Turret.
6-pr Q.F. Gun Truck in foreground.

FIG. 2.—Accident illustrating strength of rail and sleeper type of armouring.

Open Pattern Armoured Train, 1902.

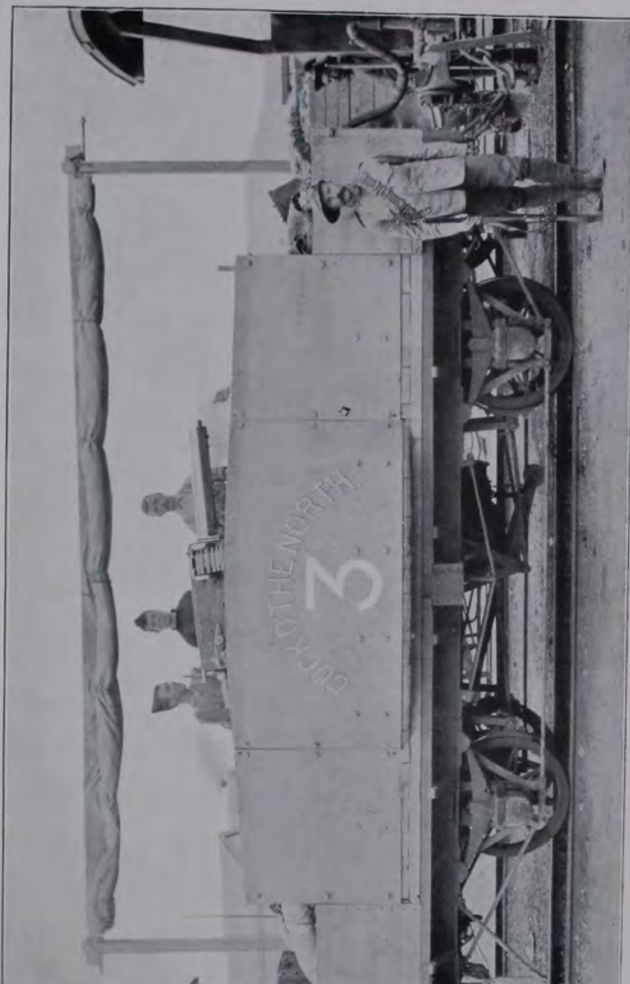
PLATE III.

PLATE IV.



12-pr. Q.F. Bogie Gun Truck.

PLATE V.



Pom-pom Truck.

PLATE VI.

Open Pattern Armoured Train, 1901.

PLATE VII.

Improvised Armoured Train.

PROFESSIONAL PAPERS.—FOURTH SERIES.

VOL. I.—No. 5.

REINFORCED CONCRETE.

BY

LIEUT.-COLONEL J. WINN, LATE R.E.

(Lecture delivered at the School of Military Engineering, Chatham, on 14th February, 1907).

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REINFORCED CONCRETE.

By Lieut.-Colonel J. Winn, late R.E.

INTRODUCTION.

The extensive development in the use of Reinforced Concrete has made it imperative that every engineer should make himself acquainted with the principles which underlie the proper design of all structures in which it is employed; and also that he should thoroughly understand the capabilities of this material, as well as the practical considerations which must be observed in the actual construction if the resulting structure is to be a success. For it has to be recognized that the failures which have occurred in the use, or, I should say, the mis-use, of Reinforced Concrete have not been caused by the inefficiency of the materials so much as by the inefficiency of the designers or constructors.

These failures—it is as well to recognize that there have been such —have brought discredit on what may be and should be a very useful addition to the materials which are utilized by the engineer. When we consider the very simple form in which these materials are found and the ease with which they can be transported, it seems to me that they are specially adapted to the use of the Military Engineer. With a few yards of broken stone, which can generally be found where proper building stone may not be easy to obtain, a few bags of cement, which are easily carried on mule-back where wheeled transport may be out of the question, a few coils of wire or bundles of light rods, which can be carried with equal ease, a small amount of water, and a few planks, which can be used over and over again, we have the materials which enable us to erect practically any kind of structure, strong, durable, weather proof, bullet proof, and fire proof.

The great variety of purposes to which Reinforced Concrete is being put I propose to show you on a number of slides* at the end of

* A selection from the numerous slides exhibited is contained in the Plates at the end of this Paper.

the lecture; and from these slides I shall be able to point out several practical points which I trust you will find useful when you come to design similar structures. In a 'Notice' that recently appeared in the *R.E. Journal* you will find that this material is being used now for bridges and barracks, for churches and coffins, for piles and pipes, for reservoirs and railway-sleepers, for sewers and silos, for piers and palaces, for seawalls and swimming baths, for weirs and warehouses, for tubes and towers, for aqueducts and viaducts, etc., etc.

Continental and American Engineers have made use of it more than we have, and for this there are several reasons. It had its origin in France; the Americans as a people are quicker to take up new ideas than we are, and moreover they are not hindered to the same extent by legislative restrictions. Though this is undoubtedly the case its use in this country is spreading rapidly, and many American firms have already established branches in London and the Provinces to supply us with the same steel goods which are being used in reinforced work on the other side. I might say here that we are in no way dependent on America for our material, as the commonest steel rods can be used and our cement is as good as any in the world; but the specialities they are selling have their peculiar advantages which I will deal with later.

GENERAL PRINCIPLES.

We know that a wire or small steel rod, hung vertically, will carry a very heavy weight; for instance, the spoke of a bicycle will easily bear the weight of a heavy man. And we also know that we cannot easily cut it with a knife. In other words, steel is capable of resisting great tensile and shearing stresses. On the other hand if we stretch the same wire horizontally it will not carry, without bending, any great weight hung upon it. We also know that steel when exposed to the air very soon rusts; and that under high temperatures it is liable to expand and also to be distorted.

Coming now to the concrete we find that this powder (Portland Cement), when mixed with water, will begin to crystallize and harden, and that it has the property of making grains of sand stick together, and that mortar made of cement and sand will cause stones mixed with it to stick together. But these stones thus cemented together can be separated without a very large expenditure of force. On the other hand the concrete, as it is called, is capable, when compressed, of resisting a pressure of a ton to the square inch without failure. We also find by experiment that its power of resisting shearing stresses is comparatively small.

We therefore see that concrete is good in compression, weak in tension, and somewhat uncertain in shearing. (Concrete is masonry made up of an innumerable number of pieces, and has therefore an innumerable number of joints).

We also find by experience that cement wash has the quality of protecting from rust any steel work that it covers; and also that concrete is a very good non-conductor of heat.

In combining the two materials we must so arrange them as to take full advantage of the properties we know them to possess; the steel must take the tension and the shearing; the concrete must take the compression, and protect the steel from the effects of fire and the atmosphere. The concrete takes the wear of any traffic, and forms the main part of the floors, walls, roofs, buttresses, etc.

BEAMS.

Figs. 1 to 4 show that by the proper arrangement of a very small amount of steel with a material possessing absolutely no power to resist tensile stresses we can produce a beam which is capable of carrying quite a considerable load.

Blocks of wood are capable of standing in compression quite a ton to the square inch, if piled one on the top of the other in the form of a column. But if we put them horizontally, and stick them together with glue or seccotine, and rest the ends of the beam thus made on supports, a very small load will make them slide downwards by shearing the glue, or, if the glue has sufficient power to resist this, the joints will be torn open at the bottom of the beam and will gape, and the whole beam will speedily collapse.

Now (*Fig.* 1) if we insert two small rods, which are not capable of bearing much load without sagging when used by themselves, and nut up the ends to prevent the joints gaping at the bottom when the load is applied, we find that a very considerable load can be carried without the beam thus made sagging to any appreciable extent.

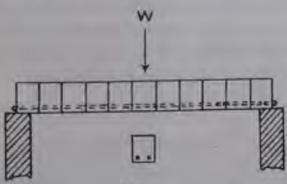


FIG. 1.

The rods prevent all the tendency of the blocks to slide on one another, *i.e.* they prevent shearing; at the same time the tendency of the joints to gape brings the rods into tension, which they are well capable of resisting; also the tops of the blocks are squeezed against each other (are compressed), and they are well able to stand this compression up to the limit of their capacity, say a ton to the square inch.

A reinforced concrete beam acts in the same way. The steel takes all the tension, the tensile power of the concrete being disregarded (and non-existent if there is a crack in it); whilst the concrete takes the compression, which decreases from the top downwards till it reaches some point towards the centre of the depth where it is nothing, this point depending on the relative resistances of the concrete and steel.

If (*Fig.* 2) we turn the beam upside down we find that, though it is the same beam, its powers of resistance are quite different. It sags under practically the same load as the rods did by themselves; the joints at once gape, as they have no power to resist tension; and the beam is a failure. (The innumerable number of joints in a concrete beam have the same tendency). The only service the rods perform is that they still prevent the blocks from sliding down, *i.e.* they resist the tendency to shear.

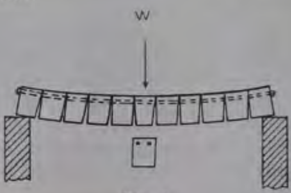


FIG. 2.

Now (*Fig.* 3) if we place the beam across *one* support and let the ends overhang, we find that, though the beam is still the same way up, it will stand a heavy weight hung on both ends, the steel being in tension and the blocks squeezed together in compression as before. From this we gather that in all cantilevers, and also in all beams and slabs which are continuous over a support, it is necessary to have steel rods *above*; for (*Fig.* 4), if we turn the beam over, we find that the joints gape at once because there is nothing to take up the tensile stress.

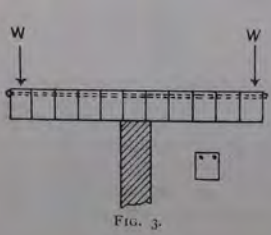


FIG. 3.

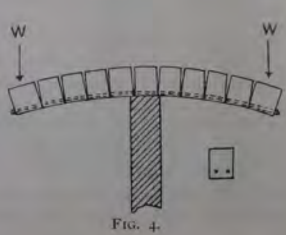


FIG. 4.

A beam, especially a deep beam, may fail in another way, namely by being unable to stand the horizontal shearing stress. I have here a model of a lattice girder, with the appearance of which we are all familiar as one spans the Medway at Rochester. If we examine it, we find that it has two booms which are connected by a lattice; and that the lattice is so designed that all the bars that slope upwards and outwards from the centre of the span are capable of taking a pull in the direction of their length, whereas all the bars that slope upwards and inwards are made to stand compression.

The reason for this is that when the load comes on the girder there is a tendency for the girder to shear vertically and *also* along its length horizontally. These shearing forces are at right angles to each other and equal to each other at any one point in the girder; so if we resolve them, the lines of resultant force will be at an angle of 45 degrees. The amount of these forces varies from the points of support, where they are greatest, to the centre, where they are small; so the strength of these tension and compression bars decreases from the ends toward the centre. These bars resist the forces which are created by the load (the weight of the girder itself and any load that may come upon it), and prevent the distortion of the girder and consequent failure.

Now exactly the same thing goes on in a concrete beam, tending to wreck it. We have seen that the concrete is well able to withstand the compression, but *not* the tension; so that in beams that are not provided with what are called shear bars (of steel) we find, from a great number of tests, that the concrete cracks in lines at right angles to the direction of the tension bars (in this model), showing clearly that it has failed from what is called diagonal tension. Therefore, to prevent this, we must provide some form of resistance, or the beam, though well able to stand the stresses in compression and tension due to bending, will fail by shearing. Many failures that have occurred have been due to the fact that this has been neglected, either from ignorance that these stresses have to be provided for or from the mistaken idea that the concrete *alone* can withstand them.

COLUMNS.

As regards members that are exposed to direct stress, such as columns and compression members in trusses, we have seen that concrete can bear considerable pressure; but if a column is subjected to an unsymmetrical load, as is often the case, it will have a tendency to bend, tension is at once set up, the concrete will crack (the joints will gape), and the column will fail. To prevent this we must insert rods to take up the tension; and since in square, octagonal, or round members this bending may take place in any direction, we must arrange our bars accordingly.

We have seen that concrete has the power to resist compression. We can greatly increase this power if we can prevent the concrete spreading or bursting under very heavy pressure; this we can do by coiling wire round it, much in the same way as indiarubber tubing is immensely strengthened by being wound with wire, and like the tube of a big gun.

We therefore see that columns should have longitudinal rods to prevent *bending* and be bound with spiral turns of wire to prevent *bursting*. About 1 % of the section of the member for the rods and about 2 % for the spirals will be found a good proportion. The wire is bound with spaces of about one-eighth the diameter of the member between the turns, and the resulting reinforced column will bear four times the load that the column would have done if not so reinforced.

ARCHES.

A word about arches. From the model (*Figs.* 5 and 6) it will be seen that when I press the arch at any point there is a tendency for the joints to gape at points which vary with the spot I press. Although there are not regular joints in concrete arches there is the same *tendency* to gape, and the concrete is not able to resist this.

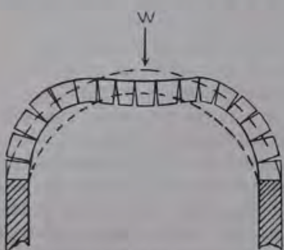


FIG. 5.

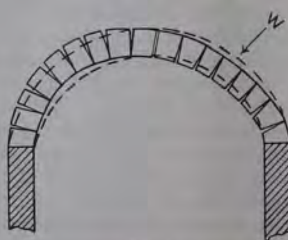


FIG. 6.

We must therefore insert rods as before; and, as you see that these gapes may occur either above in the extrados or below in the intrados, we must have continuous rods both at top and bottom. As there is also shearing set up when there is a tendency to distortion, we must provide against this by means of shear bars, as in the case of a beam.

Without going further into detail under this head we see that we must first understand what the stresses are in each part of our design; and then we must provide the necessary resistances by using the materials where and how they will best exercise the powers that we know they possess.

MATERIALS.

The powers of the materials depend upon a good many considerations.

I may mention that during the past year a special Committee, consisting of Architects and Engineers who have made a special study of this subject, has been at work. The members have made very thorough enquiries wherever Reinforced Concrete has been employed, or where reliable tests have been made; and they have come to certain conclusions which they are going to publish for the guidance of designers and constructors in this country.

STEEL.

They recommend that the steel should have the following qualities :—

(1). An ultimate strength of not less than 60,000 lbs. per square inch.

(2). An elastic limit of not less than 50 %, or more than 60 %, of the ultimate.

(3). An elongation of not less than 22 % in the lengths stated below.

(4). It must stand bending, cold, to 180 degrees (so that the internal diameter of the **U** thus formed equals the thickness of pieces tested) without fracture on the outside of bent portion.

With steel of above quality a tension of 15,000—17,000 lbs. per sq. in. may be allowed.

Test pieces should be planed or turned before being tested, except in the case of rounds less than ½ in. in diameter.

The elongation should be measured on a length of 8 in., except in the case of sections less than ⅝ in. in diameter, in which case the elongation should be measured in a length equal to eight times the diameter.

This you will notice is the specification for mild steel of good quality, and there is a strong feeling in this country in favour of *mild* steel. But it is well for us to know that in America extensive use is being made of steel having an elastic limit of as much as 55,000 lbs. per square inch.

This higher limit prevents the formation of cracks on the tension side of the beam or member, which, owing to the elongation that takes place, begin to show themselves when the reinforcement of mild steel is stressed to about 12,000 lbs. It is sought by having a higher yield point to keep this elongation within the limits that will prevent cracks.

With this higher stress there is of course a greater tendency for the rods to be pulled through the concrete, and therefore these rods are indented, or twisted, or in some way arranged so as to produce a mechanical bond between them and the concrete. I will refer to this point again when discussing adhesion, or what should more properly be called frictional resistance.

It will be understood that by using rods with this higher resistance we can use less of them; so, although this quality is more expensive in itself, still, with the smaller quantity, the difference in cost is not very great; and we shall see that these indented and other special bars have advantages which induce a large number of our American cousins to use them.

CONCRETE.

The concrete is composed of cement, sand (or crushed stone, which is better), and an aggregate of broken stone, clinker, breeze, broken brick, slag, or something else which, when combined with the cement and sand, will form a compact and solid mass when the proper amount of water is added to effect the perfect crystallization or "setting" of the cement.

We therefore see that the resulting concrete depends on the properties of all these things, and not only that but also on the way in which these things are combined. I will reserve the consideration of this point till we come to the practical details of making the concrete.

CEMENT.

Only the best cement should be used, and it should be Portland Cement complying with the specification adopted by the British Standards Committee. This specification is very complete and is rather long, so I will not give it in detail; but I would just sound a note of warning in passing. There is a vast amount of cement on the market that is not up to this standard; but as the testing can be carried out with comparatively simple apparatus, there is no reason why any engineer should have any difficulty in getting what he wants, especially as there are plenty of firms whose products are always up to the mark.

The "slow-setting" grade should generally be employed. The specification is now pretty generally known, and all firms of repute see that its provisions are observed, but this does not absolve the engineer from testing each consignment. The tests should be frequently carried out during the progress of the work as cement varies with age; it generally improves, but it *may* deteriorate, especially in warm damp climates.

SAND.

The sand should be hard, clean, and angular or "sharp"; but the chief point to see to is that the grains are varied in size. We want the resulting concrete to be absolutely solid; unless there is variety we shall find that there are many voids which are not filled up, but if the grains are of different sizes they fit into each other much more thoroughly.

As to size of grains it is recommended that at least 75 per cent. should pass through $\frac{1}{8}$-in. mesh, and any over $\frac{1}{4}$ in. should be screened out.

Tests should be made with the mortar, for sand is such a variable thing and we may find that sand that we should be disposed to avoid on theoretical grounds is practically very good. In a recent article emanating from America it was actually contended that a percentage of loamy matter improved the mortar. This led to a discussion in the technical press, but the conclusion I arrived at is that earthy matter is so uncertain in its effects that it is wiser not to run the risk of mixing it with the sand.

AGGREGATE.

We have seen that the aggregate may be of a number of different kinds, depending upon the purpose of the portion of the structure in which it is used.

Coke-breeze (not coal dust or small coke as frequently supplied), cinders, slag, clinker, broken brick (over-burnt, if you can get it) are all good fire-resisters; whereas gravel, limestone, and even granite (under high temperatures) are not. But their powers of resisting compression are almost in inverse ratio to their fire-protection qualities. Therefore we must use that material which will best meet the requirements of each case; for instance, as coke-breeze concrete is only about 30 % as strong as stone concrete, we should not think of using it unless the question of fire had to be considered, though under certain circumstances its light weight might recommend it for that reason alone for floors and partitions even when not exposed to fire risk.

As to the size to which the aggregate should be broken, we have to bear in mind that solidity is what we are aiming at. Therefore, as for the sand, so with the aggregate, we must have *varied* sizes in order that the voids may be thoroughly filled up. All under $\frac{1}{4}$ in. we have classed as sand; and none should be greater than can pass through a $\frac{3}{4}$-in. ring, so that the resulting concrete may pass between the reinforcing bars and between them and the centring.

WATER.

The water should be clean, and, in our present state of knowledge, sea water should not be used.

As to the amount, this depends on so many things—the temperature, the condition and the kind of materials, the state of the weather, and other factors—that it is not possible to give a general rule. Of course there must be sufficient to ensure that the complete crystallization of the cement takes place. On the other hand, if too much water is used it will be found impossible to ram the concrete properly.

If a hand-full is taken and squeezed just after mixing, and moisture appears, there will be ample water for the proper setting of the cement. If the concrete is to be watertight, it is advisable to mix it wet rather than to err on the dry side; but, since good ramming is absolutely essential if the concrete is to hold water, we must ensure that there is not so much water added as will make it slushy.

PROPORTIONS OF CONSTITUENTS.

We have seen that solidity is what we are aiming at, so that it is apparent that the mortar must be in sufficient quantity to completely fill up the voids. But we must not lose sight of the fact that the voids in the sand have also to be filled up by the cement.

If we measure the sand and cement separately, we find that when combined as mortar they do not occupy the same volume as they did before; and it may be helpful as a guide if I give here the resulting volumes which experience teaches us to expect from the following proportions:—

Parts, Cement.	Parts, Sand.	Parts, Mortar.
1	½	1·20
1	1	1·50
1	1½	1·90
1	2	2·35
1	2½	2·70
1	3	3·0

The amount of cement that can be got into a measure depends so much on the way in which the measure is filled, and on its shape and size, that it is now recommended that the cement (for so much depends upon the quantity of the cement) should be added by *weight*, and that for the purpose of proportioning 1 cubic foot should be taken as weighing 90 lbs.

Since the strength of the concrete varies as the quantity of the cement, the more cement we put in the better as far as strength is concerned. But on the other hand the cement is the expensive part of the concrete, so that for purposes of economy (and it is well to remember that all engineering questions are dependent on £ s. d.) we must see that no more is used than is absolutely necessary.

It has been found that concrete of 1.3.6—namely, 1 cement, 3 sand, and 6 stone—yields a concrete that will stand in compression about 2,000 lbs. to the inch after a month, and a great deal of reinforced concrete has been made with those proportions. But experience seems to point to the fact that such concrete is very "lean," and its adhesion or grip on the reinforcing bars is not enough to assure that they will not slip under high stresses. As the success of the reinforced concrete depends to a very great extent on this adhesion there has been a tendency in recent works to use a richer mixture; and I should advise most strongly that nothing less than 1.2.4 concrete should be used where the adhesion between concrete and steel is a matter of importance.

Now 1.2.4 concrete, if properly made, after a month stands over 2,400 lbs. to the inch in compression; and the Committee, of which I have already spoken, recommend that concrete which stands this can be *safely* trusted to bear the following :—

	Lbs. per sq. in.
Compression in beams subjected to bending	600
Columns under simple compression	500
Resistance to shearing	60
Adhesion (frictional resistance)...	100

With these figures we can design our structure. But we must not forget that the figures only apply to concrete of the quality above described, which has to be made in accordance with certain practical directions which I will now mention.

Before passing on to these, however, I should perhaps explain why there is a difference in the two values under compression. When under bending stress only—the extreme-fibres I was going to call them, but, of course, there are no fibres in concrete—only the portion furthest away from the neutral axis comes under the maximum stress, and the strain diminishes till it is theoretically nothing at the neutral axis; so that the less stressed portion comes, as it were, to the assistance of that under greater stress. But when under *direct* stress, as in a column, the whole area of the member is under the same stress; so it is not desirable to go beyond the 500 lbs.

This gives us a factor of safety of about 5, so that, provided our concrete is carefully made and deposited, we may feel free of all anxiety.

PRACTICAL DETAILS.

Having settled upon our proportions we must take steps to ensure that they are adhered to.

PROPORTION OF MORTAR.

I have already mentioned the desirability of having the cement weighed. It is impossible to foretell exactly what the amount of voids in the aggregate will be; so we must first find this out practically. This is best done with a water-tight box of, say, ½ a cubic yard capacity ($3' \times 3' \times 1\frac{1}{2}'$ are convenient dimensions). Fill this box with the aggregate you are going to use and ram lightly; then from a measured vessel let water flow into the box till the water is level with the top; this will give you the volume of the voids. But you will find in practice that at least 10 % more mortar than this is required to make a solid job of the concrete, so you must add this extra amount of mortar.

For ordinary work 1.2 mortar will give a strong and practically water-tight mortar, but where exceptional water-tightness or strength is required the proportion of cement must be increased.

MIXING.

In all cases the concrete should be mixed in small batches and in accurate proportions, and should be laid without delay. When the materials are mixed by hand they should be turned over and thoroughly mixed on a clean platform until the colour of the cement is uniformly distributed over the whole. The object is to coat each grain of sand with cement, and each piece of aggregate with the mortar thus produced, and the Engineer must issue such instructions as will ensure this. The old formula of 'twice dry and twice wet' may not suffice, so that I have not suggested it as the way to ensure the required result.

We have seen that the amount of water may vary from day to day, but the method of *applying it* should not, as it should always be added from the rose of a watering can and not just heaved on from a bucket or can, or, what is sometimes worse, allowed to flow on from a pipe attached to a water tap.

If for any reason work has to cease before a batch of concrete is deposited, it should not be "knocked up" on resuming work; it is far better to sacrifice a small quantity than to use what has already partially set, as this will introduce a weak spot. Contractor's foremen will do this unless it is forbidden, and even then, if they are not watched. They will tell you that it makes no difference, and they are supported in this by the opinion of some engineers. But, though surprising results have been obtained from concrete which has been disturbed in the process of setting, it is not safe to allow it in reinforced concrete, as the stresses permitted are greater than is generally borne by ordinary concrete, and also the sectional area is much less than that of the masses in which concrete was used before the introduction of the reinforcing principle.

CENTERING.

To prevent the evil effects of disturbing the concrete in the process of setting it is essential that the centering should be of such dimensions, and so constructed, as to remain rigid and unyielding during the laying and punning of the concrete. It must be so arranged as to permit of easing and removal without jarring the concrete. Provision should be made wherever practicable for splaying or rounding the angles of the concrete. Timber when used for centering may be limewhited with advantage.

Of course, for reasons of economy it is necessary to design the centering so that it may be used over and over again, or you will have to build the whole structure twice over, once in wood and then in concrete.

LAYING.

The thickness of loose concrete that is to be punned in one operation should not exceed three inches, especially in the vicinity of the reinforcing bars. Special care should be taken to ensure perfect contact between the concrete and the reinforcement, and the punning should be continued till the concrete is thoroughly consolidated.

Each section of concreting should as far as possible be completed in one operation. When this is impracticable, and work has to be recommenced on a recently laid surface, it is necessary to wet the surface; and where it has hardened it must be hacked off, swept clean, and covered with cement grout.

When it is desired to give the work a special facing, as is often done either for appearance or to make the mass more water-proof or fire-proof, it is desirable to put this on as the work proceeds, taking care that this special facing material is thoroughly incorporated with the rest of the concrete to form one mass. If the facing is put on afterwards, it is liable to peel off, and not only disfigures the work but exposes the concrete underneath to the effects it was added to prevent.

I may remark here that 1.2.4 concrete is not water-proof in itself, that is against a head; but if it is faced with three inches of 1.3 or $1\frac{1}{2}$ inches of 1.1 mortar, it will stand a considerable head as long as there is no air space between the facing and the mass of concrete behind. The absence of air spaces is ensured by working the facing and the mass together with a trowel or shovel when they are first deposited.

Work should not be carried on when the temperature is below 34° Fahr. The concrete when laid should be protected from the action of frost, shielded against too rapid drying through exposure to the sun's rays or winds, and kept well wetted. All shaking and jarring must be avoided till the centering is struck.

STRIKING OF CENTERING.

The time during which the centering should remain up depends on various circumstances, such as the dimensions of the parts of the work, the amount of water used in mixing, the state of the weather during laying and setting, etc., and no hard and fast rule can be given. The casing for columns, for the sides of beams, and for soffits of floors of not more than 4 ft. span must not be removed under 8 days; soffits of beams and of floors of greater span should remain up for at least 14 days; and for large span arches for at least 28 days. The centering of the floors of buildings which are not loaded until some time after the removal of the same may be taken down in a short time; the centering for structures which are to be used as soon as completed must remain in place much longer. If frost occurs during setting, the time should be increased by the duration of the frost.

This question of centering is a most important one, and leads to a good deal of friction between the engineer in charge and the contractor; and the engineer must also resist the temptation to early removal if he is carrying out the work himself.

To economize sheeting and centering it is only natural that those carrying out the work should want to get hold of it as soon as possible; and often as long as it is in place it interferes with easy movement and blocks up the site. So for more than one reason there is anxiety to get it out of the way. The temptation is therefore to take it down before the concrete has really set properly. This must be resisted, for not a few failures are directly traceable to the centering being either too shaky in the first place, or, if well designed, to its being removed before the concrete had hardened enough to bear even its own weight and certainly not the loads which were certain to come upon it as soon as the surface was cleared.

TESTING.

Though we have assumed that good 1.2.4 concrete will bear at least 2,400 lbs. to the inch, it is necessary that we should test the concrete to see if the particular mixture that we are using is up to that standard. For this purpose 4-in. cubes must be made, in the same way as we are going to make the concrete; and they should be punned into the moulds exactly as we propose to do with the concrete in the general construction of the work. As the results are certain to vary, it is desirable to test at least four cubes, and to take the average. The cubes should be tested by compression, the load being slowly and uniformly applied. The tests should not be made till 28 days after moulding.

As regards testing the structure itself or some part of it, this should not be done till two months have passed since the laying of the concrete. The test load should not exceed $1\frac{1}{2}$ times the accidental load, as it is a mistake to overstrain either the concrete or the reinforcement; the latter should never be stressed so as to exceed $\frac{2}{3}$rds of the elastic limit, for though the steel may be able to recover the connection between the steel and concrete may be impaired.

In making these tests it is advisable to wet the concrete, as it is much easier to detect cracks on a wet surface.

REINFORCEMENT.

I have dealt in some detail with the precautions which must be taken with the concrete, as from their neglect failures have occurred in the past, and I wish specially to sound a note of warning so that you may be saved from a similar experience.

BARS.

We must now say a word or two about the steel. We have already seen that the steel must be so placed in our design as to act in the best possible way. We must therefore see that during execution the bars are placed exactly as they occur in the plans; and not only that, we must also by thorough supervision see that they remain in the proper place whilst they are being enveloped in the concrete. As comparatively unskilled labour is employed in the rough work of concreting, there is a danger that the men may dislocate the bars without realizing that they are thereby spoiling the whole work. I have frequently seen men treading down flat the shear bars which should be vertical; and in the excellent description which appeared in the *R.E. Journal** of the wharf at Rochester, we were told that in some cases the bars had been omitted altogether. We therefore see that intelligent and careful supervision is essential, and when this cannot be ensured I do not recommend reinforced concrete.

As regards sectional area, it is desirable to use bars of small area; for they are more easily bent into any required position, they distribute the strain more uniformly through the concrete, and their surface area for adhesion is proportionately greater than a less number of large bars of the same total sectional area. On the other hand, weight for weight they are rather more expensive than the larger bars, and, of course, there is more labour in putting them in position and consequently greater expense.

Bars of more than $1\frac{1}{4}$ to $1\frac{1}{2}$ in. diameter are rarely used, and if greater sectional area is required it is better to use more bars than to exceed this limit.

Plain round bars have better adhesion than square, and square have better adhesion than flat bars.

It is manifest that the fewer welds there are the better, but if welds are unavoidable they should always be made where the strain is least. To make an effective joint it is only necessary to let the rods overlap a distance of from 24 to 30 diameters and bind them together with fine wire.

The metal should be clean and free from scale or loose rust. It should not be oiled or painted, but a wash of thick Portland Cement grout is an advantage.

* Of February, 1907.

THE 'KAHN' BAR.

Even with the greatest care the smaller bars, especially the shear bars, are liable to be displaced unless very firmly connected to the main bars. The 'Kahn' Bar, which was invented by an American engineer and is being sold over here by the Trussed Concrete-Steel Company, has wings, which are turned up at any desired angle and form part of the bar itself.

It fulfils a very useful purpose; for the wings not only provide resistance to the horizontal shear and diagonal tension, which we have seen are produced as soon as the beam is under bending stress, but, being rigidly connected to the main bar, they exercise a very great resistance to the bar being pulled through the concrete, and act as a mechanical bond in addition to producing frictional resistance between the bars and the concrete.

In the same way in columns subjected to direct stress, if these bars are placed vertically with the wings crossing in the centre of the column, they bind the whole mass together and thus tend to prevent the spreading or bursting of the concrete when the pressure comes upon it.

We see therefore that this bar possesses points of importance, and, though it is quite possible to make efficient reinforced concrete without having resort to these special bars, there is no doubt that their use gives one an added confidence. Moreover they prevent one's designs being vitiated in the process of laying by careless workmen, who, like all human beings, have a tendency to do everything in the easiest way for themselves, and, if they find that a number of small bars are constantly getting in their way, which is unavoidably the case, they either tread them down or omit them altogether.

THE 'INDENTED' BAR.

Another special bar to which I wish to draw your attention is the 'Indented' Bar. It is made by the Indented Steel Bar Company, and was introduced to ensure a thoroughly good bond between the concrete and the steel. Although, as we have seen, this bond is as a rule ample on account of the adhesion (or, more correctly, frictional resistance), still, as the whole principle of reinforced concrete depends on the absolute connection between the materials, it is well to safeguard ourselves in every way we can against this connection being destroyed; for, if it is destroyed, the resistance to the stresses coming on the structure ceases to exist and disaster must follow.

I was recently discussing this subject with an eminent engineer, who is responsible for very important public works; and he told me that he hesitated to use reinforced concrete, as he was not satisfied that the bond between the two substances would be maintained if the structure was exposed to vibration. It is clear that, if the metal is strained so that its sectional area is reduced to any extent, its frictional resistance is greatly reduced, but it is impossible to say exactly how much. However, it is only right to remind ourselves that we are designing our work, and are introducing sufficient steel, so that these excessive strains should not be anticipated, for with a pull of 15,000 lbs. on the square inch, which we have taken as our maximum, there is practically no reduction in the cross section of the metal. We also know that hundreds of structures, such as factories with moving machinery, have been erected in reinforced concrete, and, though they have been carefully inspected, there has been no sign of the connection between the concrete and the steel being destroyed.

A large number of engineers, who have erected many buildings in both Continents, consider the bond with ordinary bars so good that they never think of using anything else, though they always take the precaution of splitting and birds-mouthing the ends of their bars to give a greater hold on the concrete. However, if there is any doubt, or the least possibility that in the course of time the bond may be reduced or destroyed owing to moisture, which certainly makes a great deal of difference to the holding power of the concrete, or to any other cause, it is only sound common sense to avail ourselves of bars which, owing to their special form, make the slipping of the rods through the concrete practically impossible even though the adhesion should be reduced.

In some adhesion tests in which various bars were pulled through 8 inches of 1.2.4 concrete these 'Indented' bars stood over 1,500 lbs. per sq. in. of surface before the concrete split. Ordinary round bars tested at the same time with the same concrete failed by slipping at something over 800 lbs.

Other special bars—the Thacher Bar, the Ransom Bar, which is a square bar twisted—were tested at the same time; and though they gave higher results than plain bars, they were not quite equal to the 'Indented.'

EXPANDED METAL.

Before passing from special forms of reinforcement mention should be made of what are called "mesh" reinforcements. The best known of these is Expanded Metal, manufactured by the New Expanded Metal Company. Then there is Johnson's Steel Wire Concrete Lattice, which can be obtained 8 ft. 6 in. wide and any length; and on the other side of the Atlantic we have the Clinton electrically welded fabric.

These meshes are very convenient as they can be immediately laid in position, and this obviates the labour of making a network *in situ*. But as their sectional area is necessarily small, though the No. 69 Expanded Metal 3″-mesh gives a sectional area of 1 sq. inch to the foot-run, their use is restricted to positions where the depth is not great. They are peculiarly adapted to floors, partitions, roofs, and pipes.

AMOUNT OF REINFORCEMENT.

Having dealt with the *kind* of reinforcement we must now deal with the *amount* to be incorporated so that the strain on the concrete and steel may be well balanced. The ideal proportion would be so that both the substances should fail exactly together, and we might theorize on this point for a long time; but it is more profitable to see what we have learned from practice, and fortunately the matter has been the subject of very complete experiments.

These show that in beams of 1.2.4 concrete with varying percentages of steel, all those with less than 2 % of steel failed by the steel being strained beyond its power of resistance before the concrete failed by crushing; but beyond this proportion it was a question which material would fail first; and when the steel was considerably in excess the concrete failed in compression. We therefore arrive at this conclusion that about 2 % of steel is required to balance the concrete, if this is of the 1.2.4 mixture.

It will be understood that if we use weaker concrete, such as 1.3.6 then a less percentage of steel will be required. Also, if the aggregate consists of material, such as breeze, which will only stand about 30 % of the pressure of good stone concrete, then 2 % would be in excess of what is needed to bring both the materials to the maximum stress at the same time; and we find that those who use breeze concrete employ less than 1 % and even as little as ½ %, but then in the calculations the compression of such concrete must be taken as low as 250 to 300 to be on the safe side.

We must also remember that the tests referred to above have been made to destruction, and that when 2 % of steel is employed the stress on the concrete is far in excess of the 600 lbs. at the time when the steel fails. 1 % when stressed up to 15,000 lbs. will be more than sufficient to balance the corresponding stress of 600 lbs. which we have taken as our maximum for the concrete; so that, if we are sure that the concrete cannot be stressed beyond the very moderate figure of 600 lbs., then 1 % of steel will suffice.

In a very interesting series of experiments which he has recently completed in America, Professor Talbot ascertained by means of delicate extensometers that when he had 1½ % reinforcement the neutral axis was just midway between the compression edge and the centre of the reinforcing rods; with less than 1½ % the neutral axis was always above this point; and with more than 1½ % it was below. The interesting part of this series was that the practical experiments coincided with the results of calculations based on the assumption that the ratio of the moduli of elasticity of concrete and steel was

1 to 15. This ratio is now very generally accepted; but till recently it was taken at 1 : 10 or 1 : 12, and formulæ had been worked out on this basis which did not agree with the results of experiment.

The modulus of steel is generally taken as 30,000,000 lbs. per sq. in. That for 1.2.4 concrete is therefore 2,000,000 lbs. per sq. in., and this figure agrees with a large number of tests made on concrete blocks to ascertain this point.

CALCULATIONS.

Having established the above ratio as the basis of our calculations, we are now in a position to arrive at formulæ which can be used with confidence in the investigation of reinforced concrete with varying amounts of reinforcement.

These formulæ have been elaborated by the Committee to which I have already referred, but they necessarily entail a good many symbols and figures it would not be easy to follow now. As they will shortly be published for the information of all interested in the subject I am sure that the editor of the *R.E. Journal* will see that all the officers of the Corps are soon in the possession of them.

ORDINARY BEAMS.

However, I will venture to give you a very simple formula which, though not in the same form as that of the Special Committee, is based upon the results of the most recent investigations and agrees with the more complicated formulæ.

It is based on the fact that with 1.2.4 concrete the failure will always occur in the steel if the percentage is less than 2%, and as more than this will practically never be used, we can make use of this formula for all general purposes when dealing with beams under transverse stress; but we must bear in mind that in deep beams the failure will probably occur from shearing rather than from bending, unless we take special precautions which I will deal with below.

The formula is

$$M_r = (\cdot 9 - \tfrac{1}{25}\, p)\, Asd$$

where M_r = Moment of rupture,
p = percentage of steel,
A = Area of steel,
d = depth of beam from the top to the centre of reinforcement,
s = stress per unit of steel (15,000 lbs.).

Only the depth to the centre of the rods is taken as the depth of the beam in our calculations, the concrete below being looked upon merely as a covering to protect the steel from the effects of rust or fire.

With the following percentages of steel the portion in the brackets becomes :—

for 1 %	·86
for $1\frac{1}{2}$ %	·84
for 2 %	·82

which will be found to agree very closely with the lengths of the lever arms for the moments of resistance of the more elaborate formulæ.

T BEAMS.

In dealing with T beams

$$M_r = sAd$$

will generally be sufficient to get out your quantities without going into elaborate calculations; in this case d may be taken as the depth between the centre of the rods and the centre of the head of the T.

In calculating out the stress under compression of the T head one must bear in mind that, as it forms part of the slab, it is already under stress as a slab; and this stress, added to that which it bears as a T head, must not exceed the maximum (500 lbs.) which we have fixed upon as our safe stress, for we consider the whole area is under the same stress.

We must also ensure that the head is securely connected to the leg, for there is a great tendency for them to fail under horizontal shearing (especially if the leg is a deep one). Therefore, as the concrete should not be called upon to stand this shearing by itself, there should be steel rods in sufficient quantity running from the main bars right into the head.

The amount of this shearing force is readily obtained by dividing the reaction at the supports by the depth of the beam. This gives us the intensity at the ends, and this intensity diminishes uniformly to the centre where it is *nil*. Having found the amount, we place in the beam enough steel to resist it, taking 12,000 lbs. as the shearing resistance per inch of steel.

Having decided on the number of shear bars we mean to use (or the sectional area of each) we can at once ascertain the area (or the number) we require. A good way to locate the position of these bars is as follows :—Take the length of the beam as the diameter of a circle and describe a semi-circle on it; draw a radius vertically from the centre, and divide it into as many equal parts as there are to be shear bars in one half of the beam; draw lines through these points parallel to the beam, and from the points where these lines cut the circumference drop verticals to the beam; where these verticals cut the beam are the positions for the shear bars.

As a guide to the best depth of T beams I might mention that it is usual to make the depth from the top of the table to the centre of the reinforcement about $\frac{1}{12}$th or $\frac{1}{18}$th the span, for between these limits it will be found that the chances of the beam failing from shearing or bending is about even.

COLUMNS.

Coming to columns we have seen that 1 % of longitudinal rods to prevent bending under unsymmetrical loading, and 2 % of hooping to prevent bursting under pressure, will give us a column which will stand 900—1,000 lbs. per sq. in. with safety. But it is advisable to brace it when its length is 18 times its least dimension. For effective hooping the turns should not have a pitch of more than $\frac{1}{6}$th the diameter of the column.

PILES.

Piles have been so recently described in the *R.E. Journal** that I need not repeat what you are already familiar with.

ARCHES.

The question of arches cannot be touched upon this evening as it would require a lecture by itself. There is still a great diversity of opinion as to how reinforced arches are to be investigated, as they come between an ordinary masonry arch, in which no tension is permissible, and an all-steel arch, in which it is possible to calculate the stresses to a nicety that is not so easy in a reinforced concrete arch.

In spite of this diversity of opinion a large number of arches have been designed and are doing good service to-day. From some of the illustrations you will be able to gather some valuable hints, not only as regards the exteriors but also as to what I may call the skeleton or framework; and we can see how provision is made for the stresses that occur when the load comes on.

All I need say here is that, if you draw your polar diagram with the maximum loads symmetrically arranged; then make your funicular polygon and make the axis of the arch approximately coincide with this; then, taking 30 tons to the square foot as your permissible pressure, which will give you the thickness for the ring from crown to springing, put 1 % of steel both at the extrados and intrados (letting the rods run well into the abutments), and supply shear rods radiating from the imaginary centre of the arch—you will find as a general rule, unless the moving load is very great in comparison with the dead load (which it very rarely is with concrete arches), that you are amply secured against the deformations due to the moving load whatever its position, and you will have an arch which will practically meet all requirements.

* Of February, 1907.

The above refers to arches up to 60 feet span. With larger spans it is desirable to have hinges at the crown and the springing; for not only can the direction of the line of forces be more accurately determined and the arch designed with more accuracy to resist them, but in the actual construction any settlement is compensated for without the concrete being cracked when the centering is removed, and also all temperature changes are provided for by the two half segments rising and falling automatically.

FIRE RESISTANCE.

Our discussion would not be complete without some reference to the action of Reinforced Concrete under the effects of fire. I am able to give you the conclusions which the above-mentioned Committee have arrived at, largely as a result of the investigations of the British Fire Prevention Committee, which has tested a large number of floors and columns under temperatures rising to 2,000° Fahr. for periods up to 4 hours.

Concrete we know is a good fire resister if composed of materials which have been subjected to fire, such as breeze, slag, clinker, or bricks.

It has been our aim to ascertain what thickness of concrete should surround the steel, and also what means are necessary to keep this covering in position when subjected to simultaneous loading and fire. The conclusion that has been arrived at is that at least $1\frac{1}{2}$ to 2 inches is necessary to protect the metal in the case of beams, etc., but in the case of slabs this may be reduced to 1 inch.

We have also found from experience that the shear bars that connect the tension member to the compression region, which is not exposed to the fierceness of the fire beneath, are very useful in keeping the reinforcement in place, and indirectly assist in keeping the protecting covering beneath them from coming away under the influence of the expansion of the rods.

All angles should be rounded or splayed to prevent spalling off under heat.

RUST.

A word as to protection against rust and corrosion generally.

It is abundantly evident that it is no use relying on the reinforcement, if in the course of a few years the metal should disappear, or be so reduced in area that the stresses coming on it will be more than it can bear.

The covering must therefore be sufficient in the first place to protect the steel; and it must also be so strong as not to break away from the work and thus expose the rods to the effect of moisture or acids which have a corroding effect on the metal.

Therefore, although it is desirable for reasons of strength to put the bars as near to the tension edge as possible, when the structure has to retain water it is necessary to have between the bars and the water a sufficient thickness of water-proof mortar or concrete to protect the bars. This extra thickness will also prevent the covering from breaking away, as well as being rich in cement and therefore stronger than the rest of the wall or other member.

An inch of ordinary 1.2.4 concrete is sufficient to protect the reinforcement from the climate, but will not do for surfaces exposed to fluids. It will be found that ½ inch beneath the reinforcement of slabs will be sufficient protection from the weather, though, as we have seen, 1 inch is required for protection from fire.

COST.

Now as to cost. As the materials of which concrete is made are so various and their price varies with the locality, and as the cost of the centering varies so largely with the differing sizes of each piece and also with the extent to which it can be used over and over again, it is extremely difficult to suggest a price which will be a safe guide for general purposes.

But, as we are sometimes called upon to furnish approximate estimates, I think it is not wise to consider that stone concrete will cost in position less than 40s. per cubic yard, to which you must add 10s. for each % of metal; thus 1% of steel to a cubic yard of 1.2.4 concrete will come out at about £2 10s., and 2% will be £3.

This is using plain rods; for the special rods you will pay more, say 35%.

ILLUSTRATIONS.

I am indebted to Colonel O. E. Ruck, Major E. R. B. Stokes-Roberts, Capt. W. S. Traill, and Capt. H. W. Kelsall for sending me some information about Reinforced Concrete work, which they have either carried out themselves or which they have inspected. But the officers of the Corps have not yet taken up the question as a general rule; and when I was recently asked to write an article for an Engineering Paper on the use of Reinforced Concrete in the Army, I had to confess that at present there was not very much to say and not enough to form the matter for an article.

A few examples of work executed by our officers are given in the plates; but I have had to depend for most of the illustrations on our civil brethren, who are always so ready to show us the works that they are engaged on, and I am sure we owe them a debt of gratitude for a fund of valuable information which we as a corps have been able to utilize for the benefit of the service.

I venture to hope that the illustrations will convince us of the practical utility of Reinforced Concrete in many directions, and will encourage us to move with the times and make ourselves thoroughly acquainted with the capabilities of the materials which I have endeavoured to introduce to your notice.

NOTES ON THE ILLUSTRATIONS.

The Editor has selected from some 200 slides a number of typical examples of the various constructions to which Reinforced Concrete may be applied. We are very much indebted to the following for the loan of electro blocks and for permission to publish the illustrations concerned :—

Mr. L. G. Mouchel, Agent in England for the Hennebique Company (38, Victoria St., Westminster).

and the London agents and managers of :—

The Trussed Concrete-Steel Company (Caxton House, Westminster).

The Patent Indented Steel Bar Company (Queen Anne's Chambers, Westminster).

The New Expanded Metal Company (York Mansion, York St., Westminster).

The Considerè Construction Company (Westminster Chambers, 3, Victoria St., S.W.).

Plate A. *Fig.* 1. Shows an Indented Bar; these are rolled in sections from $\frac{1}{4}''$ up to $1\frac{1}{4}''$ square.

Fig. 2. A Double Track Railroad Bridge, 100′ and 80′ spans, reinforced throughout. 1″ bars at 12″ centres, both at intrados and extrados of arches, which are $3\frac{1}{2}'$ deep at the crown. Transverse $\frac{7}{8}''$ bars at 4′ intervals go right across the bridge.

Figs. 3 and 4. 5′ 6″ Conduit. Reinforcement—$\frac{1}{2}''$ rods at 7″ centres, with longitudinal $\frac{1}{2}''$ bars at 12″ centres.

Figs. 5 and 6. Road Bridge at Brooklyn, 85′ span. Reinforcement—$\frac{1}{2}''$ bars at 18″ centres; shear bars $\frac{1}{4}''$.

Fig. 7. Highway Culvert, 20′ spans, to stand floods rising to half way up walls. Beam continuous over central support.

Fig. 8. Arched Culvert, 18′ span, to carry highway 5′ above crown.

Plate B. Expanded Metal is made in sheets 16′ long, and the mesh varies from a $\frac{3}{16}''$ mesh of $\frac{3}{32}'' \times 24$ G. metal, weighing $4\frac{1}{2}$ lbs. per yard super, to a 6″ mesh of $\frac{3}{8}'' \times \frac{3}{16}''$ metal, weighing 9 lbs. per yard super. The strongest is a 3″ mesh of $\frac{1}{2}'' \times \frac{1}{4}''$ metal, weighing 30 lbs., and giving 1 square inch per foot-run.

Figs. 1 and 4. Detail of Suspended Ceiling, fire resisting: 3″ Expanded Metal for floor.

Figs. 2 and 3. 3′ 3″ Culvert to stand considerable external pressure. Reinforcement therefore arranged near inner face; Expanded Metal sheets, No. 10 (3″ mesh, $\frac{1}{4}'' \times \frac{3}{16}''$), overlapped on top.

Fig. 5. Protection of R. S. Joists from fire.

Fig. 6. Protection of W. I. Columns from fire.

Figs. 7 and 8. Thin and light Partitions in Dwelling Houses.

Fig. 9. Buttressed Boundary Wall, with reinforced slab foundation. No. 10 Expanded Steel throughout.

Fig. 10. Sea Wall with earth backing. 6″ ribs at 9′ centres, reinforced both sides with No. 8 Expanded Metal and connected to foundation and face slabs therewith.

Fig. 11. Tank. Covering slabs 10′ span 5″ thick; walls 8″ thick.

Plate C. *Fig.* 1. Kahn Bar, rolled; sizes from $\frac{1}{2}''$ square cores with $\frac{1}{2}''$ wings up to $1\frac{1}{4}''$ cores with $1\frac{1}{4}''$ wings.

Fig. 2. Hollow Tile Roof carried by reinforced concrete ribs.

Fig. 3. Typical Warehouse Floor. Columns carry eight storeys. Span of beams 16′. Main Beams $20'' \times 22''$, reinforced by 4 Kahn bars, $1\frac{1}{4}'' \times 3\frac{3}{4}''$. Secondary Beams $7'' \times 20''$, with one $1\frac{1}{4}'' \times 3\frac{3}{4}''$ bar. Columns 18″ square, with 4 bars $1\frac{1}{4}'' \times 3\frac{3}{4}''$ at the corners.

Fig. 4. Staircase and Viaduct.

Fig. 5. 5′ Sewer, to stand external pressure. Note interlacing of double reinforcement.

Fig. 6. Typical Retaining Walls. Walls 6″ to 9″ thick at the top, increasing towards the foot; the Kahn Bars, $\frac{3}{4}'' \times 2''$, are 12″ apart at the top, and closer nearer the bottom. Buttresses 10′ apart, reinforced with $\frac{3}{4}'' \times 2''$ bars, as are the floor slabs.

Fig. 7. Slab Culvert to carry double line of rails. The $1'' \times 3''$ bars in the slab are at 9″ centres.

Fig. 8. Arch Culvert, ditto, for larger spans. $\frac{3}{4}'' \times 2''$ bars at 9″ centres for intrados, same bars at 18″ centres for extrados.

Plate D. *Figs.* 1—4. Typical examples of the Hennebique system, showing how reinforcement is arranged in accordance with correct principles.

Fig. 5. Method of arranging rods for a skew bridge.

Fig. 6. Buttressed Abutment for the same, showing skeleton steel work, and method of connecting it to the top of the pile foundation.

Fig. 7. Water Tower 45′ high. Reservoir 10′ deep. Walls vary from 4″ thick at the top to 5″ at the bottom. Round bars, $\frac{3}{8}''$, at 4″ intervals at top of wall and closer at bottom. For details of a somewhat similar tower see *R.E. Journal*, December, 1906.

Fig. 8. Skeleton of hollow pile, 48′ long, 18″ square, cast hollow to reduce weight.

Fig. 9. Drill Hall constructed entirely of reinforced concrete, including roof members.

Fig. 10. Ferro-concrete Wharf, on pile foundation. A large number of these have now been erected in various ports of England and Scotland. They take the place of the old type of timber staging, and are indestructible by the "toredo navalis."

Plate E. *Fig.* 1. Upper surface of Arch Bridge, showing bars and stirrups in extrados. The ribs are connected by secondary beams and floor slab.

Fig. 2. Typical Wharf or Pier, showing 14″ square columns, braced with cross beams, with deck beams and secondary beams to take the deck.

Fig. 3. The Plougastel Road Bridge at Finisterre, France, designed by Mr. Considère. The elevation makes it look like a steel bridge, but it is really reinforced concrete throughout; and its fine tracery forms perhaps the most striking example of Reinforced Concrete in existence.

The breadth of the bridge is 16′ 5″ in the clear, and a mètre gauge tramway runs along the centre.

The bow is octagonal, diameter 1′ 9″, reinforced with eight $1\frac{3}{16}''$ diameter round bars, "hooped" with spirals $1\frac{1}{8}''$ diameter with a 3″ pitch.

The string is 2′ 1″ deep and 1′ 9″ wide, and the concrete envelopes 128 rods of $\frac{5}{8}''$ diameter.

The deck is $5\frac{1}{2}''$ thick, and is supported by cross girders at the panel points, which are 16′ 5″ between centres. These cross girders are 1′ 4″ deep, forming the legs of T beams, of which the deck ($5\frac{1}{2}''$ deep) is the head. They are reinforced with six $1\frac{3}{16}''$ diameter rods, and are 10″ broad.

They are connected by secondary beams, parallel with the run of the bridge, 3′ 7″ between centres. These beams are 1′ 1½″ deep and 6⅜″ wide, and are reinforced by two 1¼″ diameter rods, forming T beams with the deck.

The verticals and diagonals of the bowstrings and cantilevers are reinforced longitudinally, but are not hooped. Windbracing horizontals connect the bows when there is headroom; at other points the bows are side braced by curved members to the parapets, which are 4′ clear of the track out to out. The cantilevers are cross braced.

The main spans are 314′ 9″, the bows are 24′ 2″ deep, and the strings are 213′ long.

The swing bridge on the right is a steel structure, but all the remainder is reinforced concrete.

The estimate for the reinforced concrete work is only £12,800.

Figs. 4 and 5. Cantilever Foot-Bridge for foot passengers only, reinforced on the Hennebique system with round bars. The 90′ cantilevers are balanced by shorter cantilevers, 32·8′ long, connected to the abutments. This bridge was tested with a moving load amounting to 65 tons.

Fig. 6. Details of a Tubular Floor. The webs are made of 1.1.2 gravel concrete, and are reinforced at their bases with corrugated bands 2″ wide and $\frac{5}{16}$″ thick. In spite of having no shear bars, the floor stood a weight of 560 lbs. per foot super on a 14′ span with a deflection of only ⅛″. It resists fire well, but is too deep to be economical.

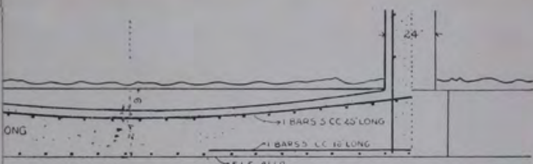
Fig. 7. Shows how reinforced concrete Floors and Columns were uninjured in the great fire at Baltimore, when buildings of ordinary construction collapsed.

Fig. 8. Shows a form of armoured concrete Roof, erected in India by Capt. Traill, R.E., which he says is easy to construct and very satisfactory. He writes:—

"The roof consists of rafters (designed to suit the span) supporting slabs. Cheapness and simplicity are aimed at; the former to admit of competition with other forms of roof where first cost is chiefly considered; the latter on account of want of skilled labour and reliable superintendence. The rafters are moulded on the ground; this admits of early removal of moulds, so very little timber is needed for moulds; when well set (after 2 or 3 months) the rafters are placed in position on the walls and the centering for slabs constructed. Bamboos are used for centering, as they happen to be the cheapest material available; the centering is plastered over with mud to get an even surface, and, in order to prevent absorption of water from the concrete, the mud is covered with oiled paper before the concrete is laid. The joint between slabs is the only original idea and is fully explained by the sketches. The work done to date has been designed for a much greater load than it is ever likely to have to bear, chiefly as a safeguard against bad workmanship. Without doubt the dimensions of joists, and therefore the cost, could be cut down. For a dwelling house in a hot climate the addition of a ceiling would give a very cool roof.

The concrete in the beams was made in the proportion 1.2.4, the stone being broken to pass $\frac{3}{4}''$ ring. The slabs were made of 1 Portland cement and 2 sand; this is extravagant, but with $2''$ slabs the excellent results seem worth it."

Fig. 9. Skeleton of Verandah Roof in India erected by Major Stokes-Roberts, R.E. The pillars and bressumers are also of reinforced concrete.



HALF SECTION

Fig. 7. Highway Culvert, Indiana.

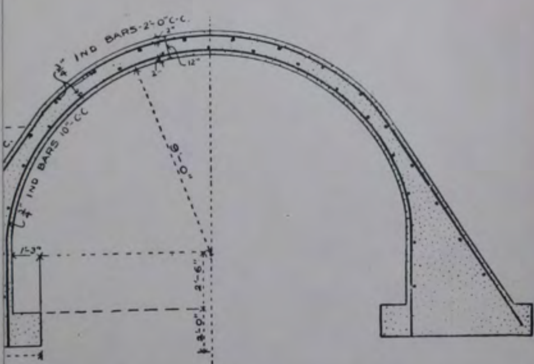


Fig. 8. Highway Culvert, Indiana.

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FORTRESS WARFARE.

BY

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Ninth, completely revised, edition of the original work by
FIELD MARSHAL MORITZ RITTER VON BRUNNER.

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PREFACE.

FIELD MARSHAL VON BRUNNER, in the preface to the 1899 edition, stated that at the time the 7th Edition (1893) appeared it required considerable courage to write a treatise on Fortress Warfare in such a precise and abbreviated form as would make it acceptable as a text-book. According to prevalent opinion at that time Fortress Warfare was a thing of the past; covered approaches were mentioned with considerable diffidence; and in some countries sappers and miners were actually abolished, while lessons drawn from the study of past sieges were deemed archaic. He was, however, quite unable to agree with the new theories regarding Fortress Warfare, which relegated assaults to the dead past. These theories were condemned alike by his own studies and experiences and by the judgment of many of his acquaintances who were peculiarly qualified to give an opinion on the subject.

By 1899, judging from the literature on Fortress Warfare published in that year and from the nature of the manœuvres, the general opinion had veered round and was in accordance with his own ideas.

In conclusion he added that, as soon as the main principles of Fortress Warfare are clearly determined, the continual changes in minor details will disappear of themselves; and he declared himself a firm opponent of the uncertainty and doubt which characterised the recent literature on the subject.

The author of this last edition, who is the son of Field Marshal von Brunner, states that the siege of Port Arthur has confirmed the general principles laid down by the Field Marshal in the earlier editions, and in many cases has proved the truth of particular details which were not to be found in any other book.

Some stress may be laid on this, because for some years prior to the Far Eastern Campaign the attack of a Fortress had been almost universally regarded as the peculiar task of the artillery and one not difficult of accomplishment, the infantry having only to give the *coup de grâce* to a rapidly defeated and completely shattered garrison.

Now, however, the pendulum of public opinion appears to have swung so far in the opposite direction that it is necessary to issue

FORTRESS WARFARE.

INTRODUCTION.

CHARACTERISTICS OF FORTRESS WARFARE.

THE science of Fortress Warfare is based on tactical principles, but yet takes into account those circumstances which distinguish it from Operations in the Field.

The Defender is in possession of a carefully chosen position, which is strengthened by artificial means, equipped with light and heavy artillery, and usually only exposed to attack from the front. He has also the advantage of a thorough knowledge of the surrounding country. He therefore enjoys the most favourable preliminary conditions for offering an obstinate resistance to attack; but it depends on the skill and energy of the commander whether these conditions are used to the best advantage.

The Defender suffers, however, from the disadvantage of having to hold an extended position with the minimum of troops; and has not the same freedom in his plan of campaign as the Attacker.

The Attacker, in order to overcome the strong resistance offered by the Defender, requires special material, particularly heavy guns; and to bring these up and get them in position demands considerable time. He is moreover compelled to make great use of field defences.

The contest round a Fortified Position will be further characterised by the constant state of alertness on both sides, and by the numerous actions which will take place under cover of night.

METHODS OF ATTACK.

The method in which a Fortified Position will be attacked depends on the strength of its defences, the power of its artillery, and the numerical strength of the garrison.

The chief object of the attack must be to accomplish the downfall of the fortress in the shortest possible time, and therefore sufficient troops and munitions of war must be available.

Judging generally from military history the following are the usual modes of attack.

(1). *Deliberate Siege.*

(1). A *Deliberate Siege* is usually the best way of dealing with a well-defended fortress, constructed on modern lines. This course of action requires great numerical superiority, a concentration of heavy artillery fire preparatory to the infantry attack, unceasing use of cover, and also special means for the destruction or neutralisation of the obstacles by which the fortress is surrounded.

Under certain circumstances even a second-rate fortress may compel the attacking side to resort to deliberate siege, especially if it is well and valiantly defended.*

Of all forms of attack deliberate siege is the slowest, but it is also the most successful.

(2). *Assault.*

(2). *An Assault* is a shorter and simpler method of attack. Its success implies either vast numerical superiority in the attack or a lack of skill or proper equipment in the defence. The artillery available will generally be field guns and field howitzers.

Several assaults may take place in the course of a deliberate siege, if the prospects of their success are favourable.†

(3). *Bombardment.*

(3). *Bombardment* is a method of capturing a fort solely by heavy artillery fire without any infantry attack at all.

Success by this method can only be obtained against weak and obsolete works defended in a half-hearted manner.

(4). *Coup de Main.*

(4). A *Coup de Main* is an attempt to force an entry into a work by surprise. This method is only possible when the defender has neglected to take proper precautions, and is generally only adopted against isolated works.

* At Port Arthur in 1904–05 the girdle of forts was too close in and the works were not well built. Yet these disadvantages were counterbalanced by brilliant leadership (chiefly due to General Kontradenko) and by the courage and endurance of the garrison. Belfort in 1870–71 was unprepared for siege. Yet it possessed a bold commander (Colonel Drufert) and the attacking force was of insufficient strength. Sevastopol was also ill prepared, but was brilliantly defended by General Todleben, and was also not cut off from its base.

† Near the commencement of the Siege of Port Arthur one or two advanced posts and two works in the main line of defence were taken by assault. Their enormous losses and the impossibility of obtaining further success in this manner compelled the Japanese to resort to deliberate siege operations. It was only against 203-Mètre Hill that assaults continued to be made, and in this case they succeeded after tremendous sacrifices in capturing the hill; the first attack was made on the 20th September and the work fell on the 5th December, the casualties amounting to 10,000 killed and wounded.

(5). *Blockade.*

(5). *Blockade* consists in starving a fortress into surrender by completely cutting it off and thus preventing the defender from obtaining any supplies from outside. In the end the defender is bound to surrender or else break through the investing lines.

This is a very slow process, and is only justifiable when the attacking force is too weak to adopt any other method and the possession of the place is essential.*

If it is only desired to keep the defender shut up in the fortress, in order to prevent him from taking part in hostilities elsewhere or from threatening the lines of communication of the attacking army, a force equivalent to about an army corps wiil be detailed to "observe" the fortress and to oppose any attempt of this nature.

If the fortress is strongly garrisoned it may not be possible to carry out these "observation" duties except by a more or less complete investment.*

We may now proceed to consider in detail the Siege and Defence of a Fortress, and in conclusion the guiding principles for the attack and defence of Barrier Forts and Coast Defence Works.

* Metz, 1870.

PART I.—THE SIEGE OF A FORTRESS.

1. GENERAL REMARKS.

THE NORMAL COURSE OF A SIEGE.

The main attack is directed against one section of the girdle of forts, the capture of which will either ensure the immediate fall of the entire fortress or else will be largely instrumental in bringing this about. The portion of the line of forts against which this attack is directed is called the 'Front of Attack.'

The siege usually begins with an Investment of the place, so that its garrison is prevented from taking part in hostilities in any other portions of the theatre of war and is also debarred from obtaining food or ammunition from outside.

As soon as possible the preparations for the siege proper are made. These consist in drawing up the Plan of Attack and collecting the necessary heavy guns and ammunition. During this time the sites chosen for the heavy gun emplacements will be attacked, if they are in occupation by the defence.

As soon as the heavy guns have been mounted in their emplacements the Artillery Duel begins, with a view to establishing a permanent superiority of fire over the defence and of inflicting as much damage as possible upon the works to be attacked. During the artillery duel the first stage of the attack is made. This consists in occupying the front, right up to the line of forts, with infantry carefully entrenched and supported by artillery fire.

After further preparation by both rifle and artillery fire, and by mining and approaches carried out by engineers, the final Assault is made, which, if successful, gives the attacker the possession of the work.

All these stages of the attack are aimed against the main point of attack, yet no opportunity should be lost of obtaining a success against other sections of the line of defence.

TROOPS AND MEANS REQUIRED.

A siege will generally be undertaken by a large Army Corps, which, in addition to its ordinary establishment, is furnished with siege parks and special troops for the purpose.

The attack must have a large numerical superiority over the defence, amounting to a proportion of about 2 to 1.*

* At Port Arthur there were originally 2, then 3, and finally 5, infantry divisions in the attack, while the defence amounted to only 2 divisions.

A *Siege Artillery Park* consists of several hundred siege guns with stores and ammunition. It should be divided into several sections. To grapple with a large modern fortress it is considered that at least 400 siege guns will be required.*

A light field railway is also necessary for the supply of ammunition to the siege guns.

A *Siege Engineer Park* contains principally tools for making earth-works and timber structures required in connection with the provision of cover for the artillery and infantry. It is also plentifully supplied with explosives and appliances for the final assault, especially escalading ladders and portable bridges for crossing ditches.

In addition to the ordinary establishment of the army, the following troops are very desirable :—

Several field howitzer divisions (of 3 batteries of 4 6″ howitzers and an ammunition column), specially for the commencement of the attack.

Some companies of fortress artillery (1 to every 6 guns), both to serve the guns and to work in the Siege Artillery Park.

As many engineer companies as possible, and also railway, search-light, balloon, and telegraph companies. A search-light section works one 90-c.m. or one 35-c.m. projector. The working height of a captive balloon is 300—500 mètres; in favourable weather single companies or batteries can be recognized at a distance of 6 kilomètres.

Conduct of the Siege.—The staff of the Commander-in-Chief will be supplemented by a Chief Engineer and a Chief of Artillery; and all the subordinate leaders should also have similar officers on their staffs.

As a deliberate siege involves great expenditure in personnel, material, and time, it should only be undertaken when the possession of the fortress is absolutely necessary and no other means of obtaining it are practicable.

This might be the case when the fortress defended an important river, railway, or road; or when it contained some valuable arsenal or dockyard; or for political reasons; or if the war could not be terminated by any other means. Otherwise sieges are to be avoided.

2. INVESTMENT AND PRELIMINARY HOSTILITIES.

BEGINNING OF THE INVESTMENT.

The reconnoitring cavalry should advance with the utmost secrecy. They should endeavour to arrive on all sides of the fortress simultaneously, and to ascertain to what extent the defender has taken up advanced positions and in what direction he has made any extensive preparations. In such reconnaissances the cavalry should be accompanied by officers of the general, artillery, and engineer staffs.

* At Port Arthur 252 siege guns and 216 field and mountain guns were employed in the attack. At Strassburg, which was an obsolete type of fortress without any girdle of forts, 241 guns were employed.

If the attacking force includes a large body of mounted troops such as the Corps Cavalry, the following duties may be allotted to them in addition to those of simple reconnaissance :—To drive in the outpost line, cut the railway and telegraphic communication, destroy the water supply, and remove all stock and cattle which might be useful either for food or transport purposes.

In order to enable the cavalry to carry out these services thoroughly, they must be supplemented by horse artillery, mounted infantry, and engineer companies, and where possible with a balloon section. If they are sufficiently strong and are led with energy, the cavalry can harass the defenders to such an extent as to hinder very materially their preparations for resisting the main attack.

The main army will advance as quickly as possible, each Division proceeding direct to that sector of the investing line to which it has been allotted. At this stage the first engagements with the advanced posts are likely to occur ; and in order that these may be entered upon without delay, every column must have its complement of field artillery, siege howitzers, and engineer detachments.

It may happen that heavy artillery may be necessary before even these advanced posts can be captured, and therefore these preliminary engagements seriously delay the completion of the investment.*

SELECTING THE LINE OF INVESTMENT.

The *Line of Investment* is a fortified position completely surrounding the fortress, and containing the camps of the investing troops ; and is designed to prevent any counter-attack or attempt to break out on the part of the defence.

This line should be pushed forward as close to the fortress as possible, because there will then be less ground to fight for in the later stages. At the same time, if the defence is energetically conducted and is provided with heavy and long range guns, the line of investment will probably at first have to be outside the effective range of these guns, because the attacking side will not yet have its own heavy artillery to reply to them.

It will soon be evident, from the amount of resistance met with, at what points the investing line may be advanced towards the fortress, and in this matter the physical conformation of the ground naturally plays a great part.

ORGANIZATION OF THE LINE OF INVESTMENT.

The Line of Investment will be divided up into Sections. The boundaries of these should be natural obstacles if possible ; but on no account should they be roads, or railways, or any line of communication.

* At Port Arthur eleven weeks elapsed before the investment was complete ; but this was partly due to temporary cessation of hostilities.

Troops will be allotted to each sector according to its extent and importance; the sector in which the assault is to be made being most heavily garrisoned, and also those in which a counter-attack may be expected.

The troops in each sector will be divided into Outposts and Reserves; and in order to maintain the proper reliefs, the former should not require more than ⅜ of the total troops allotted to the sector.

The Outposts will as a rule be stationed in the line of investment. The Reserve will be under cover close in rear.

Under certain circumstances, however, as for instance in very undulating or broken ground, it may be necessary to push the outposts in front of the line of investment. This has the advantage of securing the reserve from surprise, and also of getting a closer touch with the enemy; but it suffers from the disadvantage that the outposts have to fall back if attacked, and in so doing mask the fire of the reserves. If therefore the outposts are pushed forward the points of support in the line of investment must be held with great strength.

Where the outposts are in the line of investment, they do not of course fall back if attacked, but are at once reinforced by the reserve.

In addition to the local reserves there should also be a General Reserve stationed in rear of the most important section of the line of investment.

ARTILLERY TACTICS DURING THE INVESTMENT.

Besides co-operating in the attack on the hostile advanced posts, the attacking field and siege artillery must engage any of the hostile batteries which are inflicting damage on the attacking troops, and must endeavour to destroy any works in progress, and must also assist in repelling any counter-attack.

As regards the works in progress at this period, these will chiefly be the clearing of the field of fire in the foreground and between the different works, but this alone may give employment to several thousand men.

If the ground near the line of investment affords good cover considerable effect may be obtained from individual guns even at extreme ranges, and therefore each heavy gun or howitzer should be employed directly it arrives.

OCCUPATION OF THE LINE OF INVESTMENT.

This consists in:—

(*a*). Entrenching the Line of Investment with temporary works, which will gradually be improved by the addition of overhead cover, obstacles, etc. The system of communication, telephonic and otherwise, requires careful organisation.

(*b*). Provision of shelters for the troops.

(*c*). Careful sanitary precaution, which, owing to the duration of a siege, are particularly necessary.

(*d*). Precautions against an attempt to relieve the fortress. This duty must usually be left to a separate army, which should seek to engage the relieving force at as great a distance from the fortress as possible.

If this is not possible, and the investing army has to protect its own rear, then the investing line must be fortified against attack from both sides. As soon as the investing line is occupied the cavalry of the attack will be available to reconnoitre in rear and give notice of the advance of a relieving force.

3. PREPARATIONS FOR THE SIEGE.

DETERMINATION OF PLAN OF ATTACK.

This includes the selection of the 'Front of Attack,' the general allotment of troops for the attack, and the arrangements for bringing up the siege park, which, if a siege appears to be unavoidable, should be already collected and put on rail.

The data required for drawing up a suitable plan of attack—such as, the condition of the defence works, the arrangements for defending the intervals, etc.—must be obtained by reconnaissance and balloon observations. In choosing the front of attack that portion of the enemy's position will be selected, the capture of which can be most easily effected and will be most instrumental in the downfall of the entire fortress.

The chief requirements will therefore be :—

(*a*). A tactically important position, so that the capture of the front selected may bring about the fall of the remaining works as soon as possible.

(*b*). Proximity to the railway line of communication, so that heavy guns, etc., may be easily brought from the main line by means of a field railway.

(*c*). A front which is not too strongly defended.

(*d*). Suitable ground, offering good artillery positions and plenty of cover for the infantry attack, and soil favourable for the necessary entrenchments.*

It is not to be expected that any point will satisfy all these requirements ; so it will be necessary to carefully weigh the advantages and disadvantages against one another.

* At Port Arthur the stony ground greatly increased the difficulty of making entrenchments and the lack of earth necessitated the use of an enormous number of sandbags.

The front of attack must be wide enough to make a large gap in the girdle of forts, so that it may form a suitable base for further operations. Usually 2 or 3 main forts, together with the subsidiary works between them, and possibly the intervals on each side, are attacked simultaneously; while the neighbouring forts are kept under a heavy fire to prevent them from co-operating.*

If sufficient troops are available to make a demonstration at another point this would be very advantageous. Such demonstrations, if taken seriously, may of themselves cause the defender to neglect some other portion of his line and so give the attack an opportunity for a surprise.†

ALLOTMENT OF TROOPS FOR THE ATTACK.

The more important sectors of the line of investment will already have had additional troops allotted to them.

It now remains to supply that sector which contains the front of attack with whatever troops are necessary for the section of attack.

It is impossible to lay down definitely what these requirements will be, as they will naturally vary according to circumstances; but it may be roughly estimated that from 2 to 4 infantry divisions will be required.

The section of attack will be further divided between divisions and brigades, each of which will have a definite task allotted to it and will be furnished with its own artillery, engineers, and technical equipment.

FORMATION OF SIEGE PARKS.

For this service all available railway lines will be employed up to a point beyond the range of the defenders' artillery, roughly 10 kilomètres. From this point a field railway will be constructed to take the stores to the sites selected for the Artillery and Engineer Parks. These sites should be protected as much as possible by the conformation of the ground, and should be outside the effective range of the defenders' artillery.

Roughly speaking, 1 train is sufficient to transport 4 guns with their ammunition, etc.; and therefore in the case of a large fortress about 100 trains will be required for the entire siege train.

* At Port Arthur the main attack was directed against a section on the north side, some 4 kilomètres wide, which contained 3 permanent forts (Sungsushan, Erlungshan, North Kikwanshan) and several subsidiary intermediate works.

† At Port Arthur such a demonstration was made against the advanced position on 203-Mètre Hill to the west of the fortress. It was only after the capture of this position that a successful artillery fire was opened on the fleet anchored in the harbour, as prior to this there had been no place suitable for observing the effects of the fire.

It is almost impossible to establish a modern siege artillery park without a field railway, owing to the enormous number of vehicles and horses that would otherwise be required. A railway is even more necessary to keep up the supply of ammunition.*

The *Siege Artillery Park* is divided up as follows:—

(1). The *Gun Park*, which contains the guns and wagons and their equipment. This will be installed at about 8 kilomètres from the works attacked.

(2). The *Ammunition Park*, for which damp-proof and fire-proof buildings are required. This includes:—

(*a*). Powder Magazine, which must be 10 kilomètres from the nearest hostile work and should be very thoroughly protected. Later on this magazine may be moved nearer.

(*b*). Ammunition Magazine, which may be a little nearer and which should contain 1,000 rounds per gun (equivalent to about 32 tons per gun).

(3). *Artillery Laboratory*, which should be in front of the powder magazine.

(4). *Repairing Shops*, near the Gun Park.

(5). *Stores for Construction of Gun Emplacements* which should be placed as close as possible to the battery positions.

(6). *Artillery Transport Depôt.*

(7). *Field Railway Depôt.*

The *Engineer Park* will be established in a large depôt, 6 to 7 kilomètres from the works attacked. Later subsidiary depôts will be laid down close to the stores for making gun emplacements.

Several weeks will be required to bring up and park all the stores belonging to the Siege Artillery Park.†

The time that elapses before the arrival of the Siege Park must be utilised in collecting the necessary material for constructing gun emplacements and other works (*e.g.* timber for the platforms and overhead cover, and brushwood, etc., for the revetment of parapets). During this time also the ground selected for the gun positions must be occupied and strongly defended; but before this is done the method of employing the artillery must be decided on.

* This was clearly proved by the experiences at Port Arthur. It may be mentioned that the Japanese were very well supplied with materials for railway construction.

† At Port Arthur a large part of the siege artillery opened fire 8 days after the completion of the investment, but this was due to the fact that during the previous 11 weeks of hostilities a large portion of the siege park had been sent forward some considerable distance and was forwarded by successive stages as opportunity offered.

4. EMPLOYMENT OF THE ARTILLERY.

ITS RÔLE IN THE ATTACK.

The general duties of the attacking artillery are :—

(1). To obtain a superiority of fire over the artillery of the defence.

(2). To destroy, or damage to the utmost extent, the works of the defender.

(3). To exercise a moral effect on the garrison.

In order to carry out these duties the guns of the siege park, the howitzer brigades, and the field artillery will be established opposite the point of attack, the remaining guns being employed against other sections of the fortress.

The following are the special duties of the artillery allotted to the section of attack :—

(*a*). The fire from the forts and batteries in the section of attack must not only be kept under, but the works themselves must be destroyed if possible, and for this purpose should be heavily shelled with 24-c.m. (10½″) mortars or other ordnance of equivalent power. Small works may be entirely destroyed by such a fire, and stronger ones will have their defensive strength greatly diminished by the damage done to their escarps, obstacles, and gun mountings.

(*b*). The nearest works on each side of the section of attack must be silenced. If they are permanent works very large howitzers or mortars will be required (*e.g.* 24-c.m. mortars). If they are only semi-permanent 10 or 15-c.m. (4″ or 6″) howitzers will suffice.

(*c*). The hostile artillery stationed in the intervals must also be silenced, and their arrangements for bringing up ammunition under cover of night hindered as much as possible by a sweeping fire over the rear of the batteries and, where possible, by enfilading their railway line.

(*d*). As soon as the infantry attack begins, the personnel of the defence must be subjected to a heavy fire, beginning with the garrisons of the advanced posts. As regards the infantry positions in the intervals, these will probably already have suffered during the shelling of the batteries in the intervals ; nevertheless additional batteries should be detailed for this purpose as soon as the advance is ordered. 10 and 15-c.m. howitzers are most suitable for this work.

During the later stages of the infantry attack it will be necessary to push forward field guns and field howitzers well to the front. These guns will be required to assist in repelling counter-attacks, and to shell any small work that has hitherto escaped notice. The howitzers will be used to shell the infantry trenches, which can no longer be done by the heavy guns in rear for fear of hitting their own troops.

(*e*). The batteries and infantry positions on each side of the section of attack, which are able to hinder the attack, will be treated in the same way as works actually in the section of attack, while all other sections will be harassed by the artillery of the attack as much as possible.

(*f*). The repulse of counter-attacks is chiefly the *rôle* of the field artillery.

(*g*). The lines of communication radiating from the centre of the fortress to the different works should be enfiladed as much as possible, as also the lateral communications. Where this is not possible, certain points which must be crossed by traffic, such as bridges and defiles, should be heavily shelled. (Shrapnel from 12 or 15-c.m. guns).

(*h*). All accessible and important military and civil buildings, except hospitals, should be shelled (High Explosive shells from 12 or 15-c.m. guns).

(*j*). Shrapnel should also be used against balloons and observatories.

It should be noticed that all the above functions of the artillery can be carried out from concealed positions by indirect fire.

To successfully accomplish the tasks allotted to it, the artillery of the attack must be greatly superior to that of the defence. This superiority does not consist only in the number of guns, but also in :—

(i.). Their alacrity in opening fire so as to surprise the enemy.

(ii.). Obtaining an enfilade fire where possible, whilst never offering the enemy an opportunity of using the same fire against themselves.

(iii.). In the fact that the objective in the fortress is more easily seen and therefore more easily hit. Moreover the batteries of the defence are often massed too close together owing to want of space.

(iv.). In the fact that usually the defender's artillery is not all of the most modern type.

On the other hand the defender may have a great advantage if he is able to command and observe all the foreground within artillery range, either from observations or balloons. The defender will also be greatly benefited if the attacker has only a few lines by which he can bring up his artillery, as they can then be easily kept under constant fire. In such cases the construction of batteries will be impossible by day and very costly even by night, and it will be extremely difficult to comply with the incessant demands for ammunition.

Of course the morale and efficiency of the troops on either side also affect the question very greatly.

DISPOSITION OF BATTERIES.

The further the artillery position is from the line of forts, the less the chance of the batteries suffering from the fire of the defence; but also the less will be the effect of their own fire.

With regard to fire effect certain prescribed distances are desirable according to the calibre of the gun and the rôle allotted to it, and these should be adhered to where possible. It is therefore desirable to avoid changing the position of batteries which have once been suitably sited.

The heavy guns (*e.g.* 12 and 15-c.m.) can be placed furthest away as their target is generally larger, and in this case the range may be 8,000 to 10,000 yards; heavy howitzers will produce great effect at a distance of 5,000 yards.

The bulk of the artillery, and particularly the guns which have to contend with the hostile batteries stationed in the intervals between the forts, should be established between 2,500 and 3,500 yards from the line of forts.

The guns to assist in the infantry attack must be much closer, about 1,500 yards; but these guns will naturally not take up such a position till a later stage of the attack is reached.

It should be noted that the siege artillery must not be extended in a 'Line,' but rather in a 'Zone' of considerable depth.*

COVER AND COMMUNICATIONS FOR BATTERIES.

The guns of the siege artillery will be mounted in temporary works, holding from 2 to 6 guns each. For heavy mortars, batteries of 2 to 4 pieces are most suitable; for light guns, howitzers, or mortars (up to a calibre of 10 c.m. or 4") batteries of 6 pieces are better; and for all other types batteries of 4 pieces will be found most advantageous.

The works should be constructed with the minimum amount of excavation so that they can be completed in one short night. The parapet should be 7 or 8 ft. high, and the guns separated by traverses in which the ammunition recesses and the shelters are placed.

To make a 6-gun battery a company of fortress engineers or of garrison artillery is necessary, supplemented in either case by a company of infantry.

The construction of a battery includes the instalment of the battery

* At Port Arthur the bulk of the artillery on the right wing, which was established first, was from 4 to 5 kilomètres from the line of forts, while in the centre the range was 3 to 4 kilomètres. The batteries on the left wing, which were established later, had a range of only 2 to 3 kilomètres. The small effect obtained by the Japanese artillery was due to these long ranges. It is true however that for the same reason they suffered very little themselves.

depôt, that is to say the storage of the tools and materials for the work in some covered place close to the site; and arrangements for this should be made the day before the work actually begins.

Where works are made for single guns they must be connected by trenches, and similar communication must be made between batteries. Covered communication to the rear must also be provided, so that ammunition may be brought up and reliefs carried out in security.* Returns should be made from these trenches in which dressing stations, cookhouses, and latrines can be established.

Every battery should have its own observation post away from the battery, and every battery group should also have one. Every battery should have 1½ days' supply of ammunition, part of which will be stored in the battery, but the greater portion in ammunition recesses in the communication trenches.

Every group of batteries should have its own ammunition depôt with 2 or 3 days' supply in it. (N.B.—1 day's supply of ammunition amounts to 60 or 80 rounds per gun).

Telephone communication must be established between the batteries and the group commander, and between the group commander and the general commanding the section.

5. THE ARTILLERY POSITION.

CAPTURE OF THE LINE OF COVER.

It follows from the remarks already made on the choice of the line of investment, and the distance of the batteries from the line of forts, that the bulk of the siege artillery will generally be established in front of the line of investment.

To protect it, a fortified position, or 'Line of Cover,' must be established at least 350 yards in front of the guns.

This position has to be captured at a period when, owing to the lack of heavy artillery, the attacking side has not inflicted much loss on the defence, and when perhaps the defence has not been driven back as far as might be desired. It will therefore often happen that the occupation of this position will only be accomplished with heavy losses, and even then that the attack will not be able to advance as far as desirable.

In order to keep the defence in doubt as long as possible as to the part of the position selected for the front of attack, it is advisable to make an advance against some other portion of the fortress, and so lead the defender to believe that this is the portion selected for the main attack. For this reason the points selected for these advances should be opposite those portions of the front where an

* At Strassburg the personnel of one battery returning to quarters across the open lost 20 men from one shell.

attack would not be improbable; otherwise it will be unlikely to deceive the enemy. In any case the sections on each side of that selected for the main attack should be threatened, as this will at least deceive the defence as to the extent of the front of attack.

By such an advance against several points it is possible to draw the whole line of investment closer round the besieged fortress.*

The artillery positions must be put into a state of defence directly the artillery is established.

An unnecessarily early occupation of the artillery position is not to be commended, because its maintenance is difficult in the face of a defence as yet unimpaired, and it offers the defenders facilities for a successful counter-attack.

METHOD OF ATTACK.

It is essential that all available field howitzers and every piece of artillery should be actively employed, the greater portion being directed against the front of attack. Against a strong defence it may be necessary to bring into position some of the siege artillery as well as the siege howitzers and field artillery.

The occupation of the position itself—apart from any struggles round the isolated advanced posts—will take place by pushing forward skirmishers under cover of night. From the actions of the enemy at this stage—such as the use of search lights, a heavy artillery and rifle fire, or a series of counter-attacks—it will generally be possible to judge where larger bodies of troops can be brought up to carry out the work of putting the position into a state of defence, the skirmishers being able only to provide cover of a very temporary nature for themselves.

From this stage the work will be carried out on successive nights, and the position will be protected by outposts a few yards in front. The position selected for protecting the artillery will be gradually fortified by establishing isolated posts and connecting them by covered communication; and in carrying this out liberal use must be made of splinter-proof cover and some kind of obstacle.

The next step will be to provide trenches for the regimental and other reserves, and these should be thoroughly concealed.

After this, covered communication to the rear will be established, to permit of the safe advance of the supports under hostile artillery fire, and to facilitate the transmission of orders and the withdrawal

* At Port Arthur in the first place the Russian posts on the Wolfsberg (in the north) and on the heights of Takushan and Tsaokushan had to be taken. The first of these was captured without much difficulty on the 30th July, and the artillery which was established there opened fire on the 7th of August. Supported by this artillery a successful attack was made on the remaining heights on the 8th and 9th of August, and more artillery was established on these positions. As already mentioned however the artillery positions generally were not sufficiently advanced.

of wounded, for an uncovered advance or retirement from the position by day will be attended with enormous loss. On account of the enormous traffic these trenches should be at least $4\frac{1}{2}$ ft. wide at the bottom.

The flanks of the position will be turned back towards the general line of occupation, and emplacements for field guns should be provided on the flanks.

GARRISON OF THE LINE OF COVER.

As long as the protective position remains defective in cover, it will be vacated by day, with the exception of outposts and machine-gun detachments. But when the construction of the gun emplacements is started, it must be occupied day and night, as at this period the counter-attacks of the defence must be repulsed at all costs.

Whether in other sections of the general line it will be possible at this stage to occupy the line of investment will depend on the strength at disposal. It is very desirable to do so if possible, as it keeps the defence in doubt as to the point of attack.

6. ESTABLISHMENT OF THE SIEGE ARTILLERY.

This includes the laying of the field railway, the construction of batteries for the guns of the siege artillery, the transport of these guns from the parks in rear to the batteries, and lastly the mounting of the guns and the arrangements for storing ammunition.

GENERAL PRINCIPLES.

In order to forestall and surprise the enemy by the sudden establishment of a superior artillery fire, it would be desirable to bring up the majority of the artillery in the course of one or two nights, so that a heavy fire could be suddenly opened simultaneously from all these guns. It would then be very difficult for the defender to reinforce his existing strength in artillery on the front of attack by bringing up and mounting other heavy guns. This would greatly favour the rapid attainment of superiority of fire which is the main object at this period.

But to bring up and mount a large number of heavy guns in a few hours is one of the most difficult operations of a siege. Thousands of men, vehicles, and horses have to be set in motion on the road, with very little room to move in ; and this movement, quite apart from any action the enemy may take to impede it, is always attended with much confusion.

To move a single 6-gun battery of 15-c.m. howitzers by road requires 100 vehicles and 250 horses, and the length of the column is 1,400 yards. On a field railway 30 double trucks and 60 horses are necessary, the column in this case occupying 550 yards. The personnel required is 1 company of pioneers or garrison artillery. To move the entire artillery, amounting we will suppose to only 200 guns, the requirements would therefore be some 70 companies of artillery or pioneers, with 3,000 vehicles and 8,000 horses, and to this must be added the troops necessary to make the communications, magazines, etc.*

In peace manœuvres it has frequently been found impossible to complete during the night all the batteries which were begun.

Nowadays, however, the field railway is of the utmost assistance in getting guns into position, and the work is further simplified by the fact that artillery positions are much better concealed than they used to be. At the same time success chiefly depends on the following factors—"Good fortune, good weather, and good ground."

Thus as a rule several days must be allowed for bringing heavy guns into action. In attempting to open a surprise fire on the defence, it is therefore advisable to take several days (or rather nights) over the work of establishing those guns which are thoroughly concealed from the enemy's view, and then to bring into action on the last night only those guns which are visible to the enemy.

The construction and arming of batteries by day should only be attempted when the sites are so well concealed by the natural conformation of the ground that they cannot be observed even from balloons. With this exception all batteries should be constructed by night.

In view of the many preparations which have to be made, it is very likely that the defender cannot be deceived as to the direction of attack; and in this case he may confidently be expected to impede as much as possible the work of getting the artillery into position, both by heavy artillery fire and by sorties. Finally it may easily occur that the siege guns are not at hand when the moment for their use arrives,‡ and too much time may be lost in waiting for them.

Under these circumstances the project of bringing all the siege artillery into position simultaneously may have to be abandoned, and a portion only mounted at greater range and interval than that finally

* Recent history gives many examples of such attempts to establish a number of heavy guns simultaneously.†

† At Strassburg in 1870 an attempt was made to get 13 batteries into position under the most favourable circumstances and without opposition on the part of the defence; but the guns could not be brought into action by the following day. At Verdun, 1870, the attackers succeeded in getting 10 out of 11 batteries into partially prepared positions—without interference from the enemy; but 2 batteries, which had suffered some damage on the first day, could not be brought into action on the second day. Paris cannot be quoted as a fair example, as the conditions were particularly unfavourable.

‡ Port Arthur.

required, its irregular disposition at extended interval allowing every advantage to be taken of natural cover. By these means the defender will be deprived of the opportunities of obtaining the best effects from his artillery, and the attacker may even be able to silence the guns of the defence, since these are massed. In this initial struggle the siege and field howitzers will co-operate with the heavy guns already in position.

How and when the remainder of the heavy artillery can be got into position will depend on the result of this preliminary fire. If the attack can develop a superior fire to the defence a simultaneous establishment of the remaining guns will be feasible.

If the opposite be the case, it will be necessary to bring the heavy guns into position one by one in order to maintain the unequal contest and finally arrive at the necessary superiority of fire.

In both cases the additional artillery should, if possible, be established at its most favourable range, which by this time will be known. This will also be an opportune moment for moving forward into better positions the guns already mounted.

Such a change of position may also be necessary, owing to the fact that the position originally taken up was not close enough to the fortress, since at this early stage of operations it may not be possible to advance up to the required range.

It must however be borne in mind that no hard-and-fast rule for the establishment of the heavy artillery can be laid down. A satisfactory solution of such a difficult problem can only be arrived at by skilful and rapid action based on a correct appreciation of the situation.*

ARMING THE BATTERIES.

The first step is to lay the field railway line from the parks to the artillery positions. This must be begun as early as possible and continued as the general advance allows.

A separate line is required for every 50 guns, and branches must be laid to each battery or group.

The line should be concealed by the conformation of the ground, if possible, or else artificially covered from view.

As regards the batteries themselves also, those which are not naturally covered must be artificially concealed before the actual construction is begun.

In this connection the following expedient may be adopted with successful results. Some considerable time before the construction of

* The Japanese method of getting their heavy guns into position closely followed the procedure above described. They first established the guns already received at an increased range and interval (on the right flank). The remaining batteries were mounted, as they arrived, at closer range and interval. (The centre and left were some distance in advance of the right flank).

the batteries need be begun, lines of well-concealed infantry trenches are dug on the site selected for the batteries. The enemy will be so accustomed to the rifle fire delivered from this point that he will not expect artillery from the same spot, and the batteries can probably be mounted one by one without exciting his suspicion. In exposed ground the concealment offered by the infantry trenches will be most valuable.

In addition to the field railway the batteries and their communication trenches must be laid out and the battery depôts installed.

The actual construction of the batteries, the mounting of the guns, and the supply of ammunition to the expense magazines is performed somewhat as follows.

A couple of hours before dark the working parties assemble at some spot, naturally well concealed, which has been previously selected. At the same time the trucks carrying the guns and the ammunition for the day on which fire is to be opened are drawn up as close as possible.

The working parties are detailed to their various tasks; and as soon as it is sufficiently dark to relieve them of any fear of detection, they are marched to the battery depôts where they draw tools and materials for the work. From here they march to the actual site and begin work, which is carried on in the normal manner, every effort being made to get the platform down as soon as possible, because then the gun can be mounted even though much remains to be done before the work is properly finished.

The gun and ammunition should be on the spot by the time the platform is finished. The actual mounting of the gun should be performed by the same unit that is detailed to man the batteries.

For this work artillery and engineers are employed. The infantry execute the work outside the batteries, namely the accessory trenches and the communications.

7. THE ARTILLERY DUEL.

The conduct of the artillery duel will depend on the method of bringing the guns into position and also on the counter moves adopted by the defence; it is therefore only possible to lay down a few general principles.

Fire should be simultaneously opened from every available gun; but it should not begin until ample ammunition is at hand to ensure its uninterrupted continuation.

If the attack has succeeded in surprising or deceiving the defence by the opening fire, the battle is already half won, since it probably will not be possible for the defender to bring his reserve of heavy artillery into line at all, especially if their present position is known to the attack.

If, on the other hand, the defender, by a masterly disposition of his artillery, is able to surprise the attackers before the latter's full artillery strength can be developed, the attackers will be at serious disadvantage; and all their efforts must be devoted to bringing up the whole of their mobile artillery (siege and field howitzers, etc.) in order to develop a fire equal to that of the defence.

The rôle allotted to the various calibres has already been described in Section 4 (page 153) and should be adhered to as much as possible.

The first object aimed at must be to overwhelm and put out of action those hostile batteries which are capable of inflicting the greatest damage; for until this is done the various guns of the attack will be unable to carry out the rôle allotted to them.

Thoroughly efficient fire control is the only foundation for success, and this in its turn depends on a clear delineation of the target and a perfect system of telephonic communication or visual signalling. The Group Commanders must be thoroughly acquainted with the plan of attack and with every change in the general situation.

The fire will generally be continued with diminished intensity by night, in order to prevent the replenishment of ammunition and the completion or improvement of the various works of the defence. It will also be directed against the outpost position; and in order to disturb the rest of the hostile troops, it is advisable to shell the camps by night to a certain extent.

The damage received during the day will be repaired at night and the ammunition for the next day will also be brought up under cover of darkness.

The artillery duel, continued in this manner, may after some days lead to a perceptible weakening in the hostile fire, in which case the desired result will have been easily attained. But more often it will last for weeks and even months.*

* At Sevastopol, which was an incomplete and unfinished fortress, it lasted 10 months.

Port Arthur affords few lessons as regards the artillery duel, because the artillery of both sides reached but a poor standard of efficiency. The Russians had only medium guns and no reserve, and owing to the inadequacy of their railway and other communications were unable to move their artillery to comply with their varying requirements. They were unable to hinder the Japanese in getting their guns into position or to affect them seriously in any way; and so they preferred to reserve as many guns as possible for the close attack.

The Japanese had not a properly organized siege park. There was also an insufficiency of guns, especially medium and heavy. Only eighteen 28-c.m. coast defence howitzers were available, and these required concrete platforms; they opened fire at a late period of the siege, some in the beginning of October, 1904, and the others a month later. The Japanese were therefore unable either to silence the hostile guns or to do much damage to the works or the garrisons.

8. THE CLOSE ATTACK.

The close attack consists in occupying with infantry, by a series of rushes, the ground right up to the line of forts, the infantry attempting to establish a superiority of fire. The artillery and pioneers support this advance in every way and make preparations for the final assault. The tactics of these three arms will be considered separately.

Against a watchful and gallant defence the advance may take weeks or months.* But if every advantage is taken of any or every mistake made by the defence it may be accomplished in much shorter time.

A. THE INFANTRY ATTACK.

Its Characteristics.

In fortress warfare the infantry attack differs from that in the field by its increased duration, and by the constant use of cover which is necessitated—though this was also a characteristic of attacks on field defences in the South African and Manchurian campaigns.

A further distinguishing feature of fortress warfare is that the advance to new positions is always made by night.

Its Course.

The infantry attack must generally begin before the artillery duel is quite over, as it is usually impossible to wait until the latter is finally decided. A complete silencing of the enemy's artillery before the beginning of the infantry attack—which at one time was considered essential—can hardly be hoped for, judging from the experiences of Sevastopol, Belfort, Paris, and Port Arthur.

The defender will employ field guns and howitzers to repel the infantry attack, because they can be well concealed and easily and quickly moved when desired.

Though the artillery duel will not be over before the advance begins, it will generally be advisable to wait for a diminution in the intensity of the hostile fire; for the advance will then be less costly in casualties, and also a larger number of guns will be available to shell the hostile infantry trenches and so assist the general advance.

The advance by rushes involves the necessity of sending out the outposts by night gradually closer and closer to the line of forts. The positions of these outposts, artificially strengthened and with covered communication to the rear, form the nucleus of the next line of trenches (Infantry Position), from which fire can be maintained against the opposing works and which are of great assistance in checking counter-attacks.

In this way a position in front of the selected works and intervals

* Sevastopol 8 months, Charlestown 18 months, Port Arthur 5 months.

(Assaulting Position) is finally reached, from which, owing to the superiority of fire on the side of the attack, an assault may be made under favourable circumstances.

In face of an obstinate defence, however, an assault across the open may be impracticable. In this case further covered approaches or saps are necessary right up to the glacis of the works to be stormed; and then mining will finally have to be resorted to. (Advance by Sap)

It is impossible to lay down any hard-and-fast theoretical rule as to the circumstances under which the attacking commander will be justified in omitting any of the above stages of the attack and substituting a bold assault. Every energetic and bold leader will be in favour of assault, and can only be judged by the result of his attempt.*

It must however be borne in mind that in the last stages of every fight trivial incidents will often have a great effect on the measure of success or failure. These incidents can very often be foreseen, for it is permissible to take liberties with a garrison known to be lacking in determination or composed of inferior troops.

If there is reason to husband the forces at disposal, such undertakings should be well considered before they are attempted; indeed, against permanent works held by unshaken troops they at all times offer little hope of success.

Its Execution.

The advance by rushes, as already mentioned, is preceded by the advance under cover of night of the outposts, who entrench themselves and by artificial means strengthen their position to the utmost.

To facilitate this advance it is advisable to push forward small detachments as far as possible beyond the existing line of outposts. These detachments send out patrols to reconnoitre, whilst they entrench themselves in the positions they finally take up and strengthen the important points with the aid of pioneer detachments sent with them. They utilise every favourable opportunity of delivering an effective fire, but avoid serious conflict with superior forces.

Entire freedom of action must be given to these detachments, with the exception of instructing them as to the general direction of their advance; they are then in a position to take advantage of any

* Thus before Port Arthur the Japanese, in order to gain possession of the main line of defence, assaulted the two Panlungshan redoubts (which were not permanent forts, nor even storm-proof) from 19th to 24th August, 1904. The losses in the assaults amounted to 15,000 men, 2,300 being killed. Further severe losses were incurred by the Japanese owing to the fact that, although they captured the actual redoubts the garrisons were always exposed to a murderous fire from other Russian works. In view of the enormous losses sustained and the small results achieved this assault must be regarded as a distinct failure; and it was 4 months (1st January, 1905) before the whole front of attack was captured.

favourable opportunity which may offer, and by their advance they do not expose the troops in rear to danger as these are still protected by the outpost line. This course is generally adopted both in France and Russia and was also adhered to by the Japanese.

The above procedure provides the necessary halting points in the advance of the main line of outposts, and until this has taken place the ground cannot be considered as occupied.

The progress of the advance will vary in the different sections of attack, as it is dependent on the local resistance offered and the nature of the ground. At the same time the necessary cohesion must be maintained, and above all there must be the closest connection between the troops occupying the extremities of each section of attack.

Constructing elaborate defences cannot go hand in hand with fighting. Work in the exposed front line is subject to continued interruption from sorties and alarms. The defences hastily improvised by the detachments and outposts sent in advance are not sufficient to ensure the maintenance of the ground just won, or to develop a suitable fire. Protected by their outposts, who are now again further in front, the infantry with all available pioneers will amplify them into complete and well-connected trenches so as to form an adequate infantry position.

Location and Arrangement of Infantry Positions.

The first infantry position, which corresponds to the old 1st parallel,* should if possible be pushed out to such a distance beyond the artillery position as to be within effective range of the hostile outposts, which may either be within the line of forts or some distance in advance of it.

The final or assaulting position, which replaces the old last parallel, should be 200 to 300 yards from the enemy's works—not further, so as to avoid overstraining the troops in the final assault—not nearer, so as to avoid casualties from their own artillery fire shelling the works and intervals.

How many intermediate positions there should be depends chiefly on the ground, but the fewer the better.†

It may here be pointed out that all the positions taken up by the outposts are not afterwards completed into parallels or infantry positions. It will often happen that the outposts can only advance a very short distance at a time, and no advantage would be gained by converting the new line into a position ; moreover several of the

* On account of the necessity for the attacker to obtain protection from the enfilade fire of the defender and on account of the direction required for his own fire, the infantry position is parallel to the front of the attack. Hence the origin of the old term 'parallel.'

† At Port Arthur there were from 3 to 6 infantry positions or parallels.

outposts' positions, though the best available at that distance, may be quite unsuited for further development.

In laying out the infantry positions the conformation of the ground and the available natural cover must be utilised to give a good field of fire. As a rule they will form one more or less connected line, and the different sections should be approximately parallel to the enemy's front (L in *Fig.* 1).

The flanks will generally be open, as it will seldom be possible to rest them on natural obstacles; therefore they must be protected from the position in rear, so the first infantry position will be the longest and seldom less than 5 miles in extent.

The infantry positions must of course be made as strong as possible and provided with head cover, etc., as otherwise they will be untenable. Further it is essential that each position should be in covered communication with the one in rear. These are provided by saps (S in *Fig.* 1) which are zigzagged to prevent them being enfiladed. The returned ends (W) of the saps form wings to admit of troops passing each other.

In the infantry positions and also in the communications there must be room for bodies of troops to move, and for wounded men and ammunition to be carried to and from the firing line; so a wide trench is necessary. The trench must also be deep to afford cover from the enemy's fire, and this results in a strong parapet.*

A typical section of an infantry position is given in *Fig.* 2.

This is also suitable for the covered approaches; but if the ground allows, the trench should be deeper and the parapet lower.

Six feet must be regarded as the minimum breadth for the bottom of trench, and the final or assaulting position must be wide enough to allow of escalading and other material being carried along it.

The infantry positions must be provided with numerous splinter-proof recesses for ammunition and for telephone and observation stations, whilst in the wings of the approaches tube wells and latrines, etc., will be placed. At all crossways signposts with lanterns should be provided to show the direction to different portions of the firing line.

The drainage of the trenches must be carefully attended to, and all this work will be carried out by the pioneers.

Construction of Cover in Infantry Positions.

The execution of any important work must not be begun until night has fallen, and the working parties must be protected by outposts pushed out in front. Moreover, the search lights, either by

* At Port Arthur, on account of the rocky ground, the Japanese had to be content with shallow trenches and sandbag parapets. But where possible trenches some 10 ft. deep were dug, and the sunken ways, dongas, and streams in the vicinity were all utilised as covered approaches.

dazzling the lights of the enemy or by throwing a cross ray in front as a screen, must endeavour to prevent the working parties being discovered. This is most important as, even if the enemy's artillery has suffered severely, he will still have sufficient artillery at his disposal to destroy any work that is discovered at a time favourable for its destruction.

The men of each working party should belong to the same unit, and pioneers must be supplied to supervise the work.

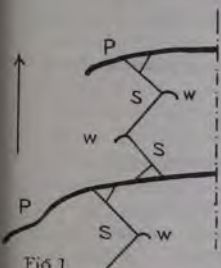


Fig 1.

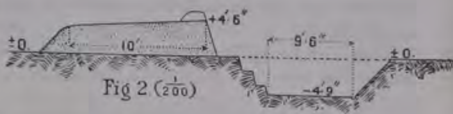


Fig 2. ($\frac{1}{200}$)

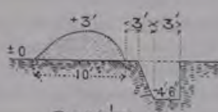


Fig 3. ($\frac{1}{200}$)

The work itself may be carried out according to circumstance in one of the following ways.

(*a*). Gradual Completion of the Hasty Defences made by the Outposts.

Those works made by the outposts which lie in the line decided on for an infantry position are connected with each other, completed, and provided with all the necessary recesses. This work is executed by a party of infantry and pioneers, who wait for a suitable opportunity and carry out the work as quickly as possible. This method involves least risk but is somewhat slow.

(*b*). Simultaneous Construction of Long Lines of Trenches by Flying Sap.

In this case large bodies of men are extended to two paces along the line selected; so that after the first night there is already a covered way along the whole front, the type of trench being similar to that shown in *Fig.* 3.

This can then be completed by successive working parties, the reliefs being continuous if possible. The approaches are constructed in the same way.

When this method is adopted it is necessary to have detailed tables of working parties drawn out, showing the amount of work allotted to each, and the requirements in tools, etc. The organization of this work is carried out by a pioneer officer.

This time-honoured method is undoubtedly the quickest. But it requires large numbers of men and is also more liable to interruption by the enemy than (*a*). Consequently it can only be adopted at greater distances from the enemy's line, unless the defender is sluggish and inactive.*

In face of an energetic defence the methods described under (*a*) and (*b*) become harder to adopt as the distance from the enemy's line decreases, and finally they become impracticable.

At this stage the work must be almost entirely left to skilled pioneers and will be described under the section devoted to their special duties.

Thus the assaulting position, as well as the approaches to it, will almost always be left to the pioneers.

Occupation of Infantry Positions. Fire Tactics.

The occupation of the infantry positions and the conduct of the fire fight will devolve on the outposts. Owing to the proximity of the enemy these must chiefly be fighting outposts. The firing line will be in the foremost position. It is not a bad plan to place single sentries and machine gun posts in front of the position. The reserves will be in the rear positions.

If the outposts are pushed forward, either to occupy new ground or to protect working parties, the reserves will occupy the foremost infantry position.

The fire from the positions will increase in intensity as the range diminishes, and will finally be so deadly that the defenders will no longer be able to show their heads.

Experience shows that at the latest stages of the siege the defence delivers the heaviest fire by night, and therefore the attack must be prepared for this.

The attacking fire will be directed not only against the defenders' infantry but also against any insufficiently protected gun detachments and search lights.

Machine guns will be found very valuable, especially in warding off counter-attacks.

The attacking side in fortress warfare has the advantage of having, as a rule, such a plentiful supply of ammunition that there is no fear of running short.

B. SPECIAL DUTIES OF THE ARTILLERY.

The general activity of the artillery will continue without interruption throughout the infantry attack.

* At Strassburg in 1870 the fortress could be approached by flying sap, not only in close proximity but even in daylight, for the defenders either fired too high or did not fire at all.

In order to comply with the demands of the infantry a certain portion will be continuously pushed forward as the attack progresses. The field guns and howitzers detailed to accompany the attack in this manner will be mounted in the infantry positions: the same applies to the batteries told off to dismount shielded guns.

The most difficult task will be that of silencing the guns in armoured casemates or cupolas, especially those mounted in the flèches of the gorges; and to do this the siege guns will have to come within very close range (maximum, 1,500 yds.) of the neighbouring works. These guns will undoubtedly attract a very hot fire on themselves, and they must endeavour to simultaneously open a very heavy and unexpected fire, so that as much damage as possible may be done before the enemy's guns can reply.

Just as difficult is the silencing of disappearing guns, which are only vulnerable when actually firing. For both these tasks, instead of the 9-c.m. siege guns, modern Q.F. guns firing high-explosive shells are necessary.

C. SPECIAL DUTIES OF THE PIONEERS.

The demands made on the pioneers or engineers during the close attack are of the greatest importance and associated with heavy casualties.

This was especially the case before Port Arthur where, by the middle of November, the pioneers of the 9th Division had lost all their officers and more than two-thirds of their men. The Japanese were forced to improvise pioneer units during the siege. It was found that actual warfare was the best school of instruction, and owing to the slow progress of the attack plenty of time for instruction was available.

(a). *Working under protection of Sap Shields.*

When, owing to the proximity of the hostile position and the consequent intensity of fire, it is no longer possible to expose large working parties in the open, the first stages of the work must be carried out under cover of steel sap shields (*Fig.* 4).

Fig 4.($\frac{1}{25}$).

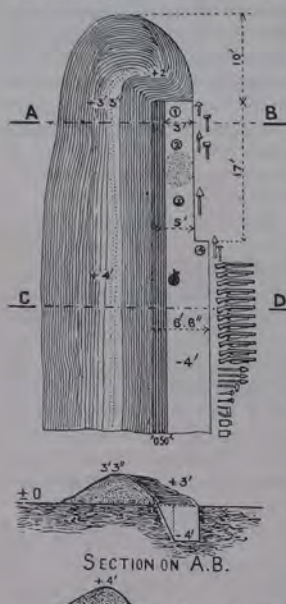
D=DIRECTION OF HOSTILE FIRE A=SAP SHIELD WITH LOOPHOLE S AND LEG B.

Fig 4 ($\frac{1}{25}$)

This work must be entrusted to pioneers only. The Japanese had no sap shields in their equipment, but found them so necessary that they had to improvise them during the siege.

(*b*). *Sapping.*

In making the covered approaches even sap shields will not offer much protection, as the trenches are no longer at right angles to the enemy's fire but inclined to be enfiladed by it; and in this case sapping must be resorted to (*Fig.* 5).



SECTION ON A.B.

SECTION ON C.D.

Fig 5. ($\frac{1}{200}$).

In a *Single Sap* a party of 4 sappers work on the trench, throwing the earth in front and on the exposed flank and thus protecting themselves from enfilade fire. The earth at the sap head is continually pushed further on as the sap progresses, so that the working party is always covered as much as possible.

Progress is naturally slow (about 4 ft. an hour).

The detail of work is somewhat as follows:—

No. 1 works at the sap head, picks down the earth, and with the scraper passes it between his legs to No. 2.

No. 2 scrapes it further back to the provisional heap shown in the figure, and then with his shovel throws it over and beyond No. 1 to form the sap head cover. When this is large enough, the rest of the provisional heap is thrown out by No. 3 to form the side parapet. No. 4 widens the sap.

As soon as 3 ft. to 4 ft. are finished the tasks are changed about. There is also a '2nd relief' and a 'reserve,' making 12 men in all.

The tool used to draw the earth back into the provisional heap is a sort of hoe or scraper, so that the work can be done in a crouching position.

The sap is subsequently widened by other parties to a width of 3 mètres.

Under certain circumstances it may be necessary to construct portions of the infantry position by sap.

Double Sap.—The closer the range becomes, the harder is it to prevent the direction of the approaches cutting the opposing firing line, which means being enfiladed.

The zig-zags therefore get sharper and sharper, and when this occurs they are completed outright by working a double sap. The double sap has a parapet on each side; it is provided with square traverses to check enfilade fire (*Fig.* 6), or else very short zig-zags are taken (*Fig.* 7).

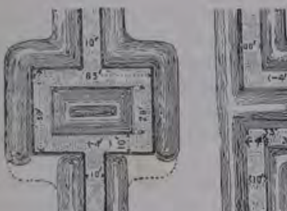
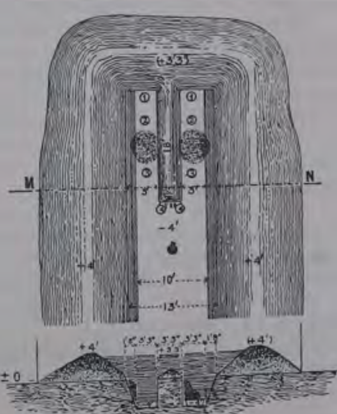


Fig 6. ($\frac{3}{800}$).

Fig 7. ($\frac{1}{800}$).

D-DIRECTION OF ATTACK
A-DIRECTION OF MOST OBLIQUE FIRE



SECTION ON MN.
Fig 8. ($\frac{1}{200}$).

The double sap is made by two sapper parties working side by side (*Fig.* 8).

At times splinter-proof overhead cover can be provided (*Blinded Sap*); this forces the enemy to have recourse to the use of hand-grenade mortars, etc.

Where sapping is resorted to every opportunity (such as pauses in the enemy's fire) will be taken to return to flying trench work.*

(*c*). *Passage of Obstacles, etc.*

Before the infantry can rush out to the assault from the assaulting position not only must the attacking side have established a superiority of fire over the defence but also the obstacles to be crossed must have been made passable.

It cannot be expected that the obstacles and the flank defences of ditches will have been sufficiently damaged by the artillery fire, and therefore the sappers will have to complete their destruction. For this purpose nightly reconnaissances must be made by sapper officers to report on the nature and condition of obstacles and galleries. It may be possible to do this by day also in foggy weather or during snowstorms.

The best method of dealing with wire entanglements, palisades, abâtis, etc., is to make gaps in them by firing charges of guncotton or some other explosive under them. Wire entanglements can also be removed by wire cutters, but the method is slow.

The escarp and counterscarp walls must be breached by explosives. This presupposes a decision to capture the fort by sapping and mining; otherwise these obstacles can only be surmounted by escalading ladders. The upper portions of escarp walls can be destroyed by 18-c.m. or 15-c.m. howitzers. Flanking galleries must be destroyed by breaching the roof or side walls; but owing to the difficulty experienced in doing this, the attack will often have to be contented with obstructing them, by firing charges outside the loopholes so as to injure the rifles, or else by throwing smoke balls through the loopholes to stupefy the garrison. Attempts might also be made to throw down sandbags to form a parapet which will give cover from the rifle fire from the loopholes.

Wet ditches must be bridged, but this will not be possible until the galleries have been destroyed.

Another very difficult task which must be attempted is the destruction of land mines, fougasses, etc., as the leads are very hard to find if well concealed.

* Saps were very largely used in the siege of Port Arthur. To avoid the labour of constantly shifting the earth at sap-head, sap shields were put up a short distance in front of the head. Blinded saps were also used, uncased mine galleries being sometimes substituted. Eventually special means had to be adopted to cope with the hand-grenades used by the Russians. (See end of Section 10, page 180).

All these works of destruction and demolition which fall to the lot of the sappers cannot be accomplished without great courage, skill, and coolness. One must rely to a certain extent on the effects of one's own fire. But hope mostly lies in the inventive talents which are the product of necessity.

9. THE ASSAULT.

GENERAL PRINCIPLES.

The assault has some prospect of success as soon as the enemy's fire—both rifle and artillery—has been considerably subdued, the obstacles made passable, and the flanking galleries either destroyed or temporarily put out of action.

It must, however, be borne in mind that the defender may be reserving his infantry fire for the moment of assault, and that he may then bring into action many guns which were thought to be out of action; and therefore one cannot from the above signs conclude that he is seriously crippled in his power of resistance, a conclusion which in an open action might safely be drawn. Moreover, damaged obstacles can be repaired at the last.

Thus the time arrives to decide whether to take risks, or to make certain of the path before the assault is attempted. In the latter case progress can only be made step by step.*

The assault in fortress warfare must be systematically organised, because of the many indispensable preparations which have to be made. An assault made at the command of an impulsive leader, though sometimes successful in the open field, is almost certain to fail against well-defended works.

As regards time, dawn is the best hour for delivering an assault. Night assaults are very hard to organise, but they have the advantage of being more or less a surprise.

An assault in broad daylight is easier to execute and can be supported longer by artillery fire; but this of course puts all chance of surprise out of the question, and would therefore involve very heavy

* The Japanese were compelled to adopt the latter method against the three permanent works in the front of attack, owing to the failure of their attempts to carry them by assault, failures which were due to the lack of proper appliances, to the well-known stubbornness of the Russian in defence, and to the type of the works which were of a storm-proof nature. The ineffective artillery fire is often mentioned as the chief and only cause of the failure to carry these works by assault; but it must be remembered that the works were not really strong, and the effect on them was probably as great as the effect of the most modern guns on permanent bomb-proof works. The conditions at Port Arthur were therefore somewhat unusual, and it must not be concluded that assaults are foredoomed to failure.

losses, except against a crippled defence or works very easy to surmount.*

Adherence to the time selected for commencing the assault should be obtained by a previous comparison of watches; signals are unreliable.

The assault should, if possible, be delivered simultaneously against several or all of the works and intervals in the front of attack, because they support each other. A simultaneous assault against all the works and intervals will not always be possible; still less must it be expected to obtain immediate success all along the line (see para. 2, page 165). At certain points it may be necessary to deliver repeated assaults or even to have recourse to sapping.†

The greater the front engaged, the greater are the chances of breaking through somewhere.

The artillery fire against the works and intervals continues until the assault begins, but occasional pauses should be made. The defending troops are thereby induced to man the parapet in anticipation of assault, and when the fire re-opens, they suffer considerable losses. A repetition of this procedure rapidly creates a disregard for alarms. During the pauses the fire may be directed on approaches or places of assembly.‡

Feints against points other than that selected for the assault should be made when possible, as they often compel the defender to split up his forces. The front line in a feint should not go so near as to endanger themselves from their own artillery fire, or to expose themselves to enfilade fire from the works on either side. They must however seize any good opportunity of capturing a work or breaking through one of the intervals.§

ORGANIZATION OF THE ASSAULTING TROOPS.

The troops for the assault of a work are divided into (*a*) Skirmishing Line, (*b*) Assaulting Columns, and (*c*) Reserve. There should be as many storming columns as there are gaps in the obstacles.

(*a*). The Skirmishing Line rushes to the edge of the line of obstacles, kneels or lies down ready to shoot any of the defenders that expose themselves, and remains in this position until the assault has succeeded beyond all doubt.

* Warsaw, 1830, Sevastopol, 1855, Duppel, 1864, and Port Arthur were all stormed by day.

† At Port Arthur the first work fell on the 22nd of August and the last at the end of December.

‡ The Japanese continued their artillery fire during the assault and their own troops suffered to a certain extent. It is questionable whether this unexampled behaviour is likely to be universally repeated.

§ Kars, 1877: the columns under Tscheremissinov and Rydewski.

(*b*). The Assaulting Columns consist of sappers and infantry. The sappers form the head of the columns, and carry the necessary appliances (escalading ladders, light bridges, etc.), which they place so that the infantry behind (25 to 30 men per column) can surmount the obstacles.

(*c*). The Reserves consist of infantry, a few sappers, and artillery.*

The assaulting columns must consist of specially selected men, who should be as lightly equipped as possible, without coats or belts, with rifles slung and ammunition in their pockets. Swords should be taken without scabbards. Awkward, heavy, or short-sighted men or officers are quite unsuitable for this work. Volunteers should be taken as much as possible, as one faint-hearted or clumsy man may bring about the destruction of the rest.† The men should have been all carefully trained and practised in surmounting obstacles.

The troops for the assault of the intervals should be formed up in the same way, and their sappers equipped according to the nature of the obstacles to be encountered. Where there are no obstacles, or where they have been entirely destroyed, the formation of columns is disregarded.

Besides the assaulting troops, sectional reserves and a main reserve must be detailed. These at first occupy the infantry position in rear, and follow up the assaulting troops if successful; but if they are repulsed the reserves entrench themselves and cover the retreat. Field artillery and howitzers must also be held in readiness for this purpose.

EXECUTION OF THE ASSAULT.

(*a*). *Assault against a Work.*

Still under cover of darkness the assaulting troops are assembled and the necessary appliances collected.

At the appointed time the artillery turn their fire on to the space behind the works and intervals; and at the same time the skirmishers rush from the assaulting position, immediately followed by the assaulting columns, and run quietly and without confusion towards the works or intervals.

At this point the situation may present a variety of aspects the chief of which are as follows:—

(i.). The most favourable aspect is when the defender is completely taken by surprise, so that the skirmishers reach the line of

* The Japanese also kept with their reserve some men armed with hand-grenade mortars (range 450 yds.).

† The Japanese carried out this principle, but to excess, on the 26th November, 1904, against Fort Sungsushan, when the assaulting columns consisted of 2,000 volunteers drawn from several divisions.

obstacles and the assaulting columns pass through them and surmount the crest of the work before the parapet is manned by the defence.

In this case the assaulting columns kneel or lie on the parapet and shoot any of the enemy that expose themselves. No attempt should be made by the stormers to penetrate into the interior of the work until they have been considerably reinforced.

The fight for complete possession may be soon ended. But if small detachments obstinately defend sections or réduits of the work, the struggle may continue for hours;* and if external reserves are brought up in support, it may even result in the attacking side being driven out again.

As soon as a work is finally taken it must be at once strengthened by sappers so as to render more difficult any attempt at re-capture; careful search must be made for the magazines and for any mines which may have been laid; still serviceable guns in the flanks and gorge must be manned; and flags should be planted in order to notify the capture to the other troops of the attack.

(ii.). The most unfavourable case is when the defender anticipates the assault, mans his parapet, and opens a heavy fire on the assaulting troops.

In this case the advance will generally be discontinued, and the skirmishing line will endeavour by the intensity and accuracy of their fire to sweep the defenders from the parapet. If this cannot be accomplished, further success will be impossible, unless the defending infantry are so shaken that they are afraid to raise their heads sufficiently above the parapet to aim at the attacking troops and therefore fire over their heads.†

As soon as an opportune moment arrives the advance will be continued.‡ But some time may elapse before this is possible, and even then it may end in failure, in which case a gradual advance by sap must be substituted for the assault.

(iii.). If the ditch has been crossed before the defenders man the parapet, the assaulting columns will collect on the berm and will climb the parapet at points where it is least swept by fire (traverses, angles, etc.). If necessary the assaulting columns must wait on the berm until

* At Kars in 1877 the masonry réduit of Fort Kanli held out the whole night after the fort itself was captured. This was due to the attackers lacking explosives for breaching the walls.

† At Toul the Bavarian contingents lay on the glacis for a long time in broad daylight without suffering any losses; but as they had no planks or appliances to cross the wet ditch, they were forced to retreat under cover of darkness.

‡ At Gornji Duburak, 1877, the Russian firing line lay for hours some 100 yards from the main trenches; then they suddenly rushed them and effected their capture.

their own troops, firing from the glacis, have cleared the defenders from some portion of the parapet.*

(*b*). *Assault against the Intervals.*

This will usually be less difficult to accomplish, as the works here will have smaller resisting power, especially in the matter of obstacles.

If the intervals are stormed and captured before the works on either side, these latter may then be taken in rear.

(*c*). *Further Advance against the Interior of a Fortress.*

It is to be supposed that the defender will have expended most of his strength in the defence of the main line of forts; the resistance to further progress will be weaker, and further attack will be consequently considerably easier.

Under very favourable circumstances—such as a successful assault without over-exhaustion, a rout of the defenders, or a failing supply of provisions for them—it may be possible, as soon as the communications, etc., have been organised, to at once proceed against the enceinte of the fortress. In the face of a vigorous defence, however, a great deal of hard work may still have to be accomplished before the next position is captured.

In any case a bombardment of the town itself should be attempted at this point as it will lend great weight to the attack.

10. ADVANCE BY SAP AGAINST A FORT.

If the defence is marked by great valour and vigilance it will probably be impossible to capture any important work by the above method. The attempts to cut passages through the obstacles may have failed wholly or partially; the destruction of the flanking defences of the ditches may not have been sufficiently successful; and the fire of the defence may be so searching that every attempt to leave the assaulting position is frustrated.

Under such circumstances the advance to the ditch must be accomplished by sapping and mining, and all attempts to storm the work deferred until the ditch is reached.

* At Nikopolis in 1877 the storming columns maintained themselves in the ditch, whilst the rest of the attacking force were repulsed, and waited there until the attack was renewed again. On the other hand in the assault on the forts of Erlungshan and North Kikwanshan on 30th September, 1904, the Japanese, who had actually gained the ditch, were driven out again, and neither work was captured until 50 days after.

MODE OF EXECUTION.

Fig. 9 shows a fort the ditch of which is flanked by counterscarp galleries. It has an infantry parapet, Q.F. guns at *s*, and an artillery position with howitzer cupolas at *h*. The foreground of the neighbouring works and the intervals are flanked by Q.F. guns firing from the position *t* over an angle *a*.

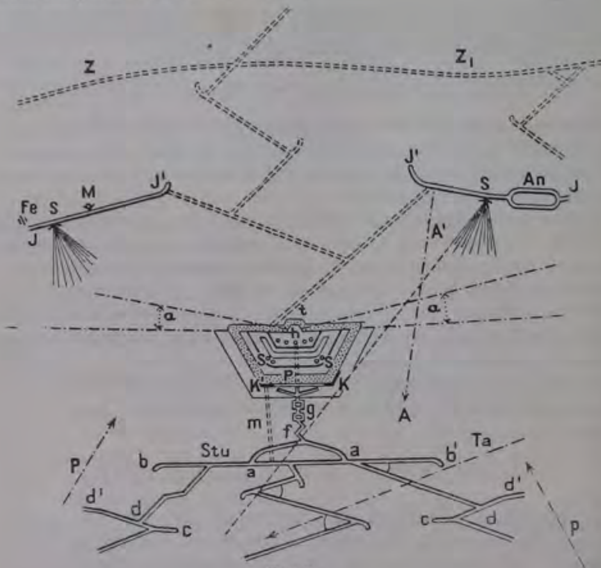


Fig 9.

T*a* marks the outer limit of the field of fire of the Q.F. guns in the gorge flèches of the neighbouring forts, and thus shows the extent to which the attacker's infantry positions and approaches can be enfiladed. JJ′ show the infantry works in the intervals. F*e* marks the field guns. M is a light mortar battery. A*n* is an enclosed battery. SS are searchlight positions. ZZ′ is the line of the intermediate batteries. A′A is the direction of small sorties. *ab′dd′* are the attacking saps and infantry positions. P is the direction of fire from the infantry supports in rear.

As a rule a bow-shaped trench (*aa*) will be laid out from the middle of the assaulting position (*Stu*). From here an advance is made to the counterscarp by short zig-zags (*f*), or by a direct sap with cube traverses (*g*), or if necessary with a blinded sap. Here perhaps the sappers will be able to destroy the counterscarp galleries KK from above by dropping charges of high explosive or by sinking shafts at the sapheads sufficiently close to the galleries to blow them up.

If there is a wet ditch the sap is taken right up to the water's edge so that a bridge can be easily thrown over.*

At this stage the withdrawal of the garrison will not only be impatiently awaited, but may easily take place unobserved.†

The gradual advance will be supported by a very heavy artillery fire against the intervals (infantry position JJ′ and the intermediate batteries ZZ′); and the parapet of the fort will be swept by infantry and machine-gun fire from the assaulting position.

In this contest the bayonet and hand-grenades will play an important part.

SUBTERRANEAN PROGRESS.

The rate of advance of a rectangular gallery, 2′ 8″ wide and 3′ 8″ high, is 1 yard in 2 to 5 hours in clay or stiff gravel.‡ For a circular shaft, 7′ 6″ diameter, 2 to 3 hours are necessary to advance 1 yard in stiff soil. With a suitable electric drill a much more rapid rate of progress might be possible; but at present no such apparatus for military purposes has been invented.

If the soil is easy, success may perhaps be more easily attained by mining from the last position up to a point whence the counterscarp galleries can be destroyed by a charge of guncotton or other explosive (see *m* in *Fig.* 9).

By further explosion the mine passage may then be converted into a covered way to the breach in the counterscarp.

If the defence still possesses an intact system of countermines, mining must be resorted to.

THE STORMING.

While this gradual and tedious advance is being accomplished every opportunity will be taken to occupy even the smallest portion of the enemy's defences.

In this everything depends on the skill and initiative of officers

* At Strassburg a barrel-pier bridge was made.

† At Strassburg, 1870, the sappers were undertaking the slow and laborious work of building a dam across the ditch of No. 53 lunette, during which they suffered severely from enfilade fire from No. 52, and on completion found the lunette unoccupied all the time.

‡ At the siege of Petersburg in America (1865) the Federals ran a gallery 160 yards long under one of the works, and blew it into the air. At Silistria (1854) and Plevna (1877), when sapping failed, mining was resorted to, and the work to be stormed was undermined. Nevertheless in the first two cases the assault was repulsed, and in the third case circumstances rendered the firing of the mine unnecessary.

and men. They should not be discouraged by failure, for there is a limit to the resisting power of the most obstinate defence; and nothing tests this capacity so much as repeated assaults.

The final success will be the sum of the previously described separate successes. But every opportunity should be taken of curtailing the operations by a general assault, if there are signs that the defence is sufficiently broken or if some dominating portion of the position has been captured.

Examples from the Siege of Port Arthur.—The difficulties experienced in capturing a well-defended permanent work are best illustrated by the gradual advance by sapping and mining against Fort Erlungshan.

After the Japanese had, on 9th October, reached some covered ground at the foot of the glacis an assault was attempted on 30th October. They reached the main ditch, but had no suitable apparatus with them to climb the escarp wall and were driven out again. The attack was renewed on 3 successive days without success.

The Japanese then determined to blow in the counterscarp wall, which they succeeded in doing on 17th November. After this assaults were made on 4 successive days, but they all failed.

They then proceeded to mine against the escarp wall, and on the 28th December, by firing a charge of 4,800 lbs., they brought down a portion of the wall and the parapet above it.

The fort was then shelled for 3 hours and at 1 p.m. an assault was made. By 5 p.m. the Japanese gained possession of the parapet, and then two battalions entered the work, and after repulsing 3 counter-attacks the work was captured at 8 p.m.

Thus after the first assault no less than 60 days passed before the fort was captured.

A similar struggle took place before the forts of Sungsushan and North Kikwanshan, which were captured at the end of December after blowing up the parapet.

At Sungsushan a magazine exploded, annihilating that portion of the garrison who were on the parapet; the rest were hemmed in the casemates by the result of the explosion.

It is noteworthy that at North Kikwanshan the capture of the counterscarp galleries took one month. Here the Russians employed countermines, but without success.

Hand-grenades* were largely used by both sides during the siege,

* Field Marshal von Brunner advocated the use of hand-grenades long before the siege of Port Arthur.

and with marked success. The Russians initiated this in their small sorties against the Japanese saps; and later on small mortars were used for hurling the grenades. The Japanese followed their example, and during the siege turned out about 100 grenade mortars, made of bamboo, which had a range of 450 yards. The Russians also had devices for setting fire to the sandbags used by the Japanese as sapheads.

PART II.—THE DEFENCE OF A FORTRESS.

The defence against a regular siege will be mainly considered in this Part. But the principles also apply largely to the conduct of a defence against other modes of attack, and supplementary details applying only to the latter will be found in Part III.

1. GENERAL PRINCIPLES.

It is the duty of the defender to hold the position entrusted to him until his power of resistance is completely exhausted, and thus to inflict upon the enemy as much injury as possible.

The prolonged resistance of a fortress not only embarrasses the enemy, but also increases the prospects of a change in the fortune of war, which may either add to the importance of the fortress itself or bring about its relief.

If the defence is faint hearted and does not make use of every advantage, even the strongest fortress will offer but a feeble resistance. On the other hand, even if the position is a weak one, it may offer a successful resistance to all attacks; for it is not the rampart but the man behind it that constitutes the real strength of a fort.

An energetic defence does not consist only of warding off the enemy's attacks. It seeks rather to forestall every effort and so nip each attack in the bud, and, taking advantage of every weakness on the attacking side, is prepared to assume the offensive at any moment. Such methods characterise an "active defence."

If the defence is not strong enough to do all this, it must at least contest every inch of the ground, make use of every defensive position, and expend all its resources in prolonging the resistance to the utmost.

The duration of the defence cannot be reckoned in days. In fortress warfare, as in field warfare, superiority lies always on the side of that combatant who excels in courage, endurance, activity, and resourcefulness.

TROOPS AND MEANS REQUIRED.

The conduct of the defence will be in the hands of the Commander of the entire fortress, whose staff will include special officers to direct the engineers and the garrison artillery.

The fortress will be divided into several Sections, each under a Commandant of high rank. Any section of peculiar size or importance may be divided into sub-sections (groups). Each Section

Commandant will be aided by sectional directors of engineers and artillery.

The garrison will include all the normal tactical units of all arms and also the following special units:—

Searchlight companies.	Railway sections.
Telegraph sections.	Mining "
Balloon "	

These will be drawn partly from the garrison artillery and partly from the technical troops.

Special attention will be given to visual signalling and wireless telegraphy. Units will be formed to work hand-grenade mortars and land mines and for the extinguishing of fires. In addition Civilian labour corps will be organized.

To the usual establishments will be added a special Artillery and Engineer Park; the former including all the guns, ammunition, platforms, etc., which constitute the 'armament' of the place; and the latter supplying the tools, explosives, etc., required in the defence of the fortress.

The strength of the garrison depends on the importance and extent of the fortress, and also upon its natural defensive strength. As a rule it only includes those troops actually detailed for the defence of the fortress, and these are known as the Defensive Garrison. In first-class fortresses a Field Army may also be under the orders of the General-in-Chief commanding the fortress, and this may sometimes be accommodated in the fortress, in which case it forms the Offensive Garrison.

The Infantry Garrison of a fortress should not be less than one man per yard of the circumference of the line of forts, and in an important fortress will therefore hardly ever be less than 50,000 men.

Cavalry will not be required in large numbers; for it is only during the initial stages that their rôle will be an important one, and it will be very difficult to make adequate provision for forage.

For orderlies and messengers cyclists will be more useful.

The strength of *Field* and *Garrison Artillery* depends entirely on the number of guns.

The number of *Sappers* or *Pioneers* should be as great as possible, as there cannot be too many of them.

Transport will be required in large numbers for carrying building material, guns, and ammunition; and mechanical transport (steam traction engines and motor lorries) should always be supplied, if possible, for these purposes.

The *strength in Guns* should be estimated on the principle that, besides the guns mounted in the forts and long-range batteries, a sufficient reserve should be at disposal to enable the defence to place in any interval against which an attack is in progress as many guns as space will allow, even in two lines when necessary. In an important fortress the number of guns of all calibres will seldom be less than 800.

DISTRIBUTION OF GARRISON AND GUNS.

The personnel will be divided between the garrisons of the different sections (or Sectional Garrisons) and a General Reserve.

The sectional garrisons are again divided into garrisons of the actual works in the section and the Section Reserve. The sectional garrisons are responsible for the independent defence of their sections until the general reserve arrives. The general reserve should be kept for emergencies, or to carry out a counter-attack.

The guns should be divided into the Defence Armament, which includes all guns mounted permanently in the works and batteries, and the Artillery Reserve, which should include both field and siege ordnance to form a mobile and a heavy reserve.

The defence armament—like the sectional garrison—is responsible for the independent conduct of the artillery struggle until the arrival of the reserve armament. It will include guns of all calibres.

The mobile artillery reserve will consist chiefly of horsed long-range ordnance, which can be quickly moved to any threatened interval in order to support the defence armament, particularly against the mobile batteries of the attack. Field and 6″ howitzers are especially suitable for this purpose; 4″·7 guns and 6″ mortars are also useful. The mobile artillery reserve, in addition to long-range guns, should include a certain number of field batteries.

A very light mortar (about 3″·5) is a very useful adjunct to the mobile reserve to shell the hostile parallels. If such are not available, 6″ howitzers may have to be used, and put in emplacements well to the rear. Gun teams are not required for these light howitzers as they can be man-handled.*

The mobile reserve should be as large as possible and chiefly composed of field howitzers. These are peculiarly adapted to engage the attacking batteries, and to shell such targets as the attacking side offer. If the mobile reserve is sufficiently large, the heavy reserve may be dispensed with, and thus the difficulty of bringing the latter into position at the required place and time is avoided.

As regards the cover required for the mobile reserve, the defender is in the pleasant position of being able to arrange for this in advance at all probable points of attack. Therefore he will almost always be able to concentrate the required number of guns at any point in

* The need of such a weapon was severely felt at the siege of Port Arthur. As a substitute hand-grenade mortars were employed; but these, though very effective, had an extreme range of only 500 yards.

good time; and this, as previously explained, robs the attacker of the fruits of bringing up his artillery with speed and secrecy.

The only disadvantage in connection with a large mobile reserve is that a very great number of horses are required if the howitzers are kept ready horsed; but this is not necessary.

The heavy artillery reserve consists of unhorsed long-range ordnance, which as a rule is not brought into position until there is no longer any doubt as to the front selected by the enemy for attack. It consists usually of 6″ howitzers*, to which may be added any old pattern guns available; their principal rôle is to engage the batteries of the attack.

A portion of the heavy reserve may be used to support the defence armament from the beginning, that is before the intentions of the enemy are apparent, in order to co-operate in repelling a surprise assault should such be contemplated. Such a course would be advisable where the front of the works lends itself to a surprise assault; but when it is adopted, only the lighter guns would be used, so that the subsequent change of position which is almost sure to be necessary may be easily accomplished.

If the employment of all the guns of the heavy reserve is postponed until the selected front of attack is definitely known, it may happen that a successful assault will lead to the capture of the reserve without any of its guns having rendered any assistance to the defence; whereas their partial co-operation might have assisted in retarding the preliminary operations of the besieger and prevented the execution of the assault.

2. PREPARATIVE MEASURES.

The first step is to carry out those preliminary works and preparations which cannot be performed in peace time, but which are necessary to enable the fortress to fulfil its rôle. These include the organization of the garrison and of its artillery, engineer, supply, and sanitary services. They will vary according to the importance of the fortress and the type of attack it will have to resist, viz., deliberate siege, assault or *coup de main*. The following pages refer only to the first.

The preparative measures will begin on the first day of mobilization and will be continued until the enemy appears. From this time the defensive strength of the fortress becomes of greatest importance and is improved to the utmost throughout the siege.

All the necessary preparative measures to be taken on the outbreak of war should be carefully drawn up in detail in peace time.

The garrison should be previously trained in defensive warfare. For this purpose during the training and manœuvre periods the occupation

* These howitzers can be used with either high or low platforms. With the former they are part of a siege artillery park and are immobile; with the latter they belong to the siege howitzer divisions and are mobile.

of works and intervals should be practised, and sorties, etc., attempted from the fortress itself, so that the men and officers may become thoroughly acquainted with the works and the ground in the vicinity.

All specially-formed units must at once be properly organized and brought under discipline.

ARTILLERY SERVICES.

The most important work in connection with the artillery is getting the guns of the defence armament into position, laying the platforms, mounting the guns, and concealing the batteries as much as possible. The next thing is the formation of the main artillery reserve, which must be kept ready in parks. The horses for the mobile reserve must be kept quite close to the guns.

Then arrangements must be made for the observation of fire, by providing observation posts and balloon stations.

Finally steps must be taken for lighting the foreground, and for the supply of ammunition, which must be stored in readiness in the magazines.

Against a *coup de main* the defence armament consists chiefly of short-range guns; against an assault of long-range guns, to which a mobile artillery reserve must be added; against a regular siege a heavy artillery reserve is required in addition.

ENGINEER SERVICES.

These comprise the completion and improvement of the defences erected in peace time and the construction of huts, shelters, etc.

The foreground must then be cleared to give a good field of fire. Dead ground should be made impassable by mines or abâtis. In densely wooded country lines of sight must be cut through the trees.

All bridges and communications, which may be of value to the enemy, will be destroyed.

All the works will be protected from surprise assaults by increasing the obstacles and strengthening them, and the works themselves will be concealed artificially. In the intervals and in rear any extra works required will be constructed.

The special work for the sappers consists in building batteries, digging trenches and communications, placing obstacles, making observatories, etc.

The existing communications will be improved by making new roads and railways, and when necessary huts will be put up for shelters and stores.

In addition to this, advanced defensive positions must be prepared outside the line of forts, and lines of trenches will be required inside.

The enceinte also must be properly fortified, the first object aimed at being to render it storm-proof.

SUPPLY SERVICES.

Supplies (including fuel, light, and tobacco) must be collected not only for the defensive garrison but also for the field army and for the civil population allowed to remain in the fortress. The amount stored should be sufficient to ensure that the fortress will not fall owing to inadequate supplies.

All foreigners, and persons useless for the defence, and also those who have not laid in the stock of provisions ordered by the General Officer Commanding, should be sent away.

As soon as hostilities are threatened all provisions, horses, cattle, etc., in the neighbourhood should be collected in the fortress to deprive the enemy of the use of them; and at the same time all the country people who have not with them an ample supply of provisions should be strictly denied refuge in the fortress.

The provision of supplies is greatly facilitated in these days by the introduction of frozen meat and condensed foods.

SANITARY SERVICES.

These include the provision of shelter and medical attendance for the sick and wounded, and what is of even greater importance the precautions to prevent the outbreak of epidemic diseases.

Each section of the defence should have its own hospital.

3. GENERAL RULES FOR THE DEFENCE.

Before going into a detailed description of the course of a defence, it will be useful to lay down a few fundamental regulations concerning the duties to be carried out in works and batteries, on outposts and reconnaissances, in isolated posts, and during sorties and counter-attacks.

DUTIES IN WORKS AND BATTERIES.

The infantry garrison of a work will be divided into guards, with their reliefs, and a reserve. The guards will occupy the flanking defences of the ditch and will also be stationed at the entrance in the gorge. The reliefs will be in readiness to man the parapets at the first alarm; a portion of them may also be told off to observing stations to watch the front, or this may be left to the guards; the remainder, without accoutrements, are retained in readiness in the bombproofs and shelters. During a bombardment the sentries and look-out posts may be withdrawn to the nearest bombproof, as no assault can take place whilst the bombardment lasts; but they must be ready to resume their places the moment fire ceases. (This does not apply to men in cupolas). The reserve ($\frac{1}{3}$ to $\frac{1}{2}$ the garrison) will be allowed to rest, but when the alarm is given they will hasten to reinforce the guards and the reliefs on the parapets.

The gunners in the works or batteries are similarly divided (gun-detachments, reliefs, and reserves). At the approach of dusk or in foggy weather the *hangar geschütze** are brought up and all guns are prepared for night firing.

In the more important works an officer will be detailed day by day to inspect.

DUTIES OF INFORMATION.

These will usually be performed by infantry patrols, single scouts, etc., and must be most carefully conducted throughout the siege. Mounted patrols can only be employed in the early stages.

The formation of an Intelligence or Reconnaissance Section, consisting of specially selected officers and men, who should not be detailed for any other duties, is recommended as leading to the best results.†

The scouts should be provided with carrier pigeons, in order to send back early information to headquarters. The most important duties of the scouts will be to reconnoitre the detraining stations and parks of the attacking force.

As soon as the fortress is threatened it will be advisable to push out small parties (from ½ to 2 companies) some two days' march beyond the fortress. These will act as supports to the patrols and send back their reports, either by telephone, signallers, or cyclists, and will also act as a check to the hostile reconnoitring parties. These detachments may be provided with machine guns and captive balloons.

Information will also be obtained by observation from captive balloons and from observatories in the fortress.

To thoroughly observe the front, it should be divided into zones up to the maximum range of view of the best telescopes; and each zone should be constantly watched by separate detachments, composed of men thoroughly conversant with map reading and having an accurate knowledge of the country.

The observing stations must be in telephone and heliograph communication with the Section Commandants, and through them with the General-in-Chief.

Observation by night may be carried out by search lights,‡ rockets, star shell, etc. The latter are very useful for this purpose, as they have a range of several thousand yards when fired from howitzers and light up a circle of some 2,000 yards diameter for 15 seconds. As the light falls from above, the shadows, which form such an obstacle when search lights are used, are obviated.

With the light-ball fired from a light-pistol a circle of 150 yards diameter can be lit up for 10 seconds at a range of 300 yards.

* These appear to be small calibre guns, which are kept under cover until required. See also last line of page 197.

† This was done at Port Arthur.

‡ At Port Arthur search lights were very useful for illuminating the foreground for a distance of 1,000 yards, and were difficult to range upon.

DUTIES OF SECURITY.

The security of the line of forts is the duty of the section reserves, who supply outposts and their necessary reliefs, etc.

The pickets are placed either in the line of works or, if possible, are pushed forward in advance. The former course is advisable if the foreground is open. If the reverse is the case, the outposts should be pushed forward, but they would fall back before a serious attack. This advanced line must not be confused with an advanced position.

Advancing the outposts simplifies the reconnaissance by the defence, whilst that of the attacker is hampered; it also gives the section reserves time to get into position before an attack. But it has the disadvantage that, in the event of a sudden attack seriously pushed home, the outposts mask the fire from the works.

The supports are told off for the occupation of any of the intervals that are attacked; as a rule 2 to 3 of these supports per interval are sufficient. Where the main line is pushed forward, they should be in close proximity to the fighting position; in other cases, they can be accommodated in shelters in retired sites.

The remainder of the section reserve will be placed to the rear in centrally situated camps or bivouacs.

To ensure regular relief and proper rest, the pickets and supports should not exceed one half of the reserve.

If it is certain that the pickets will be actively engaged, the section reserve will be reinforced by a portion of the general reserve.

The various portions of the section reserve must be in visual or telephonic communication with one another, these means being supplemented if necessary by patrols.

The duties of security can be simplified in clear weather by day and on ground that can be easily dominated, when some of the pickets and reliefs may be withdrawn.

ADVANCED POSTS.

These, as already explained, consist of fortified posts outside the line of forts. They are garrisoned by a portion of the general reserve and armed with field and mobile siege artillery.

The object of such positions is to delay the attacker, to force him into a costly engagement before he can approach the fortress, and above all to dispute with him as long as possible the possession of the ground required by him for his artillery position.

The attacker may also be compelled by the presence of these advanced positions to deploy a considerable force in a direction not previously anticipated by him;* and this may be of great benefit to

* Mont Avron on the east front of Paris, 1870.

the defence when there is a field army fighting in conjunction with the fortress.

The maintenance of these advanced positions naturally involves the defender in considerable losses which affect the later stages of the defence. Therefore, in every case it must be carefully considered whether the advantages outweigh the disadvantages.

If the defender, as is usually the case, has none too many troops at his disposal, the establishment of advanced posts will only be justified under especial circumstances, such as unusual tactical weakness of the line of forts, which may be confronted by high and dominating positions for the enemy to occupy, or an unusually contracted field of fire.*

Advanced posts must fulfil the conditions required for a strong defensive position; they must be difficult to surround and yet easy to withdraw from; and they should be supported by the artillery fire of the fortress.

The defence of advanced positions should be abandoned at the right time, that is as soon as the enemy has obtained such an advantage that the continuance of the struggle involves very serious loss to the defender or threatens to cut off his retreat.

SORTIES.

These may be divided into *Grand Sorties*, executed with a large force and with some very important object, and *Minor Sorties*, carried out by a small portion of the garrison and with objects of secondary importance in view.

Grand Sorties are a recognised means of prolonging the resistance of a fortress which has at its disposal either a very large and well-constituted reserve or else a separate offensive garrison.

* Such circumstances were present at the sieges of Belfort and Port Arthur. In both cases advanced works had to be placed where the permanent line should have been. The former was threatened by the heights of Perches, and therefore these heights were occupied as advanced posts, as they were the best possible position for the attacking artillery.

The Russian positions on the Kwantung Peninsular materially retarded the investment, but they formed somewhat exceptional examples as their flanks were protected by the sea. In the nearer foreground (*i.e.* within artillery range of the main forts) 203-Mètre Hill offered a striking example; and it was only after the loss of many lives that its capture enabled the Japanese to bombard effectively the Russian fleet at anchor in the harbour. The other similar positions delayed the attackers considerably, and were only captured by costly and bloody assaults.

The successful defence of advanced posts at Belfort was due to the numerical weakness of the attacking force; at Port Arthur it was due to the excellent quality of the troops of the defence.

The object of such sorties may be any of the following :—

(*a*). To take part in some engagement which is going on in the neighbourhood of the fortress.

(*b*). To overwhelm some isolated column on the march.

(*c*). To delay the investment.

(*d*). To destroy the batteries or other works of the attack.

(*e*). To break through the investing line if the abandonment of the fortress has been decided on.

Grand sorties should be made with as many troops as possible ; but a sufficient number must be left behind to repel any assault which may be consequent on the failure of the sortie.

They should be delivered at dawn, the troops having been noiselessly assembled under cover of night. Every effort should be made to surprise the enemy before daylight.

Feints should be made at several points to confuse the enemy and prevent him concentrating his troops.

The artillery, which should have shelled on the previous day those batteries which could play on the troops making the sortie, will fire occasionally during the night in such a way as to draw the return fire away from the place of assembly. As soon as the sortie is disclosed the artillery will shell the point of attack and all hostile troops moving to its support.

The object of *Minor Sorties* is to harass the enemy continually, to discover what his plans are and to prevent him getting information concerning the defence, to destroy his batteries and other works, and to capture small exposed detachments or guns, etc.

Minor sorties should be often repeated in order that the sum of the advantages gained thereby may be equivalent to a success on a large scale.

They are practicable even with a weak garrison ; and the main factors which make for success are skilful leadership and rapid execution.*

Machine guns and single field guns may accompany minor sorties, in order to take advantage of any exposed weakness and to enfilade parallels or trenches or troops on the march.

Grand and minor sorties are useful even if they do no more than make the enemy take extensive precautions against them. They are also the best means of keeping up the fighting spirit of the garrison.

* Minor sorties were frequently made at Port Arthur, the chief object being the destruction of trenches and other engineer works ; in these sorties hand-grenades were found to be of the utmost value.

At Verdun, 1870, two German batteries were captured by a sortie at a distance of 1,500 yards from the fortress. On the 19th and 20th October the French (some 200 strong) spiked 12 guns, and on the 28th they completely destroyed the battery.

At Arad, 1849, Lieut. Unukich (infantry) and Lieut. Desci (engineers) carried out successful sorties almost every night.

4. CONDUCT OF THE DEFENCE AT DIFFERENT STAGES.

As soon as hostilities are threatened a "State of War" should be declared, so that the Commander-in-Chief may have complete power over the civil population.

Above all the police regulations dealing with suspicious elements and strangers must be rigidly enforced. All foreigners who are either political or social suspects, in fact all persons whose presence is inconvenient in any respect, must come under strict police supervision and be eventually turned out.

DELAYING THE INVESTMENT.

The measures to be employed for obtaining information have been already described. They will be utilised to discover the time and direction of the enemy's approaches so as to seize a suitable opportunity for making a sortie.

The allotment of the defence troops will be adjusted, and the necessary safety precautions taken by putting out pickets, patrols, etc. The long-range guns are at first occupied against the enemy's line of advance and against any defiles.

The investment of a fortress—apart from the assistance of advanced positions—is most effectually hindered and delayed by grand and minor sorties and by accurate artillery fire.

Grand sorties with this object must be carried out as soon as possible, for every successive day makes their accomplishment more difficult.

As the enemy, when investing a large fortress, is forced to occupy a very extended position, it will always be difficult for him to assemble sufficient troops at the critical point in time to repulse a well-timed attack. The Commander of a large fortress with an offensive garrison at his disposal will therefore often be able to place superior numbers at any given point with every chance of fighting a successful action.

The artillery fire will be chiefly directed against the enemy's occupied positions, batteries, or cantonments. In engaging the hostile batteries the defence armament may, if desired, be supplemented by the mobile reserve.

The hostile preparations for the siege (positions of detraining stations, parks, stores, etc.) should now be discovered by scouts or by observation from balloons, and an attempt must be made to destroy them by artillery fire. The installation of parks, etc., which involves the employment of a large number of men and vehicles, can hardly be hidden from a watchful defender, who therefore will soon be able to foresee the intended front of attack.

The efforts of the attack to gain ground must be opposed by artillery and outpost fire and by minor sorties. Search lights are of great assistance in revealing the enemy's moves in this direction.

Throughout these stages, however, the possibility of the enemy's attempting an assault must never be overlooked by the defence.

HINDERING THE ESTABLISHMENT OF THE ATTACKERS' ARTILLERY.

As previously related, one of the hardest tasks for the attack is the establishment of the heavy artillery. At this period the defender has many strong well-protected batteries in position and provided with ammunition; and from his superior knowledge of the surrounding country is able to check and hinder very seriously the construction and arming of the attacking batteries.* To keep the hostile batteries at a distance is no small advantage.

All approaches, bridges, etc., which the enemy must use to transport his stores, should be shelled; also any visible lengths of railway. Those positions in which batteries may be expected to be placed, or where any unusual preparations can be seen, should be subjected to rafale fire. The value of this fire has been constantly disputed; but the author's opinion is that against objects where a single hit may cause the greatest damage and confusion (*e.g.* on transport vehicles, works, etc.), it may be most valuable, even when the position of the target cannot be definitely ascertained.

The guns should fire day and night, and this involves great expenditure of ammunition.† But if considerable disturbance and delay can be caused to the attacker whilst establishing his artillery, a success at this period will have a greater influence on the contest than subsequent exertions to wrest the superiority of fire from hostile guns in position.

The initial stages of a siege are particularly favourable for grand sorties. These should be undertaken when the enemy has already mounted a number of guns; then not only is the mounting of other guns delayed, but great damage can be done to the guns already in position and to the railway and telephone lines in connection with

* That this did not happen at Port Arthur is due to the following reasons:—

(1). The Russians had no balloons.
(2). The ground was very favourable to the establishment of batteries.
(3). The batteries were at a very long range from the fortress.

† In previous sieges ammunition has been so sparingly used that considerable amounts have been handed over when the fortress fell. At Port Arthur 8,000 rounds for heavy guns and 100,000 rounds for field guns remained unexpended.

them. The work of destruction should be entrusted to specially trained technical troops.

During these stages also every effort should be made to forestall the enemy in establishing a superiority of artillery fire, by bringing up into position the unallotted guns of the heavy reserve. (See para. 3, page 185).

As soon as the front of attack can be foreseen with some certainty the necessary steps must be taken to bring the reserve artillery into action; *e.g.* the construction of the batteries and magazines, and the preparation of the guns and ammunition for immediate use. The guns, however, should not be actually moved and mounted until the front of attack is known beyond all doubt, as a mistake in this matter is not easy to rectify.

At the same time there may be circumstances when the above course cannot be followed; for example, if the attacker has succeeded in surprising the defence by opening fire from a large number of guns before the defender has been able to make the preparations for installing the guns of his heavy reserve. In such case the defender must adopt the method laid down for the attack (see para. 1, page 162).

The conduct of the artillery duel will be considerably dependent on the result of the preceding stages of the contest, whether the defender actually has succeeded in hindering the establishment of the hostile artillery, or whether on the other hand he was himself taken by surprise.

It may however be stated that the most important and at the same time most difficult duty of the defence artillery consists in silencing those batteries which are inflicting the most damage on the principal works. The location of these batteries, which will be well concealed and at long ranges, as well as the observation of their own shells, will be almost impossible for the defence artillery unless assisted by captive balloons. The position of such batteries will often be only approximately known and in this case rafale* fire must be resorted to.

During the artillery duel the hostile infantry must never be lost sight of, for an assault may be attempted at any moment, and in this case the guns will turn their fire on to the advancing infantry.

The question here presents itself whether, when the attacker possesses considerable superiority in artillery, it would not be advisable to keep back as many guns as possible to engage the assaulting infantry. In favour of this view is the fact that, as the siege advances, more and more guns will be required for this purpose; and they can better perform this duty from positions less exposed than those from which they would engage the hostile batteries. Moreover, the attacking artillery may be compelled to take up positions at closer range.

On the other hand, if this plan is adopted, the guns thus kept in

* Shrapnel or high-explosive shell with time fuses from 6" howitzers.

rear are useless in the struggle against the hostile artillery, which may then be able to turn part of its attention against the infantry positions of the defence.

Judging from the experiences at Port Arthur, no definite solution of this question has yet been arrived at.

OPPOSING THE CLOSE ATTACK.

An extensive and well-organised intelligence and reconnoitring service, supplemented by unremitting precautionary measures, will contribute most to a successful repulse of the close attack. An early knowledge of the enemy's preparations enables the defence to deliver a heavy artillery and infantry fire in the right direction, and precludes all possibility of surprise. When the close attack begins the number of patrols and minor sorties should be increased; and, if possible, more search lights should be employed to light up the foreground.

The outposts must be strengthened according to the proximity of the enemy, and the reserves must be kept closer to the line of forts.

The progress of the close attack is best hindered by destroying the trenches or other works, which will usually only be prosecuted at night; and if these efforts are successful the hostile troops, exposed to the searchlight beams and under very scanty cover, may be subjected to severe losses.

The fire against the main infantry positions must also be maintained, and by day every effort should be made to enfilade the zig-zag approaches.

To carry out these duties against exposed targets the direct-fire guns in the works will be employed, and also the field guns which will constantly change their position. Against covered targets howitzers, firing from concealed batteries, will generally be used.

When favourable targets are offered, such as large working parties disclosed by the search lights, all guns, regardless of their particular rôles, should at once be turned on them.

In order to force the enemy to increased precautions, it is advisable, if plenty of ammunition is available, to shell any positions where it is even suspected that works are in process of construction.

The artillery must devote particular attention to the hostile batteries which are firing on guns in cupolas or on those in the gorge flèche (see para. 2, page 169).

As the attack gets closer, the value of the outpost fire and machine-gun fire increases accordingly; and night firing generally becomes more important, for by night firing especially the attack is compelled to make early use of sapping.

There are several instances in history of the defence disputing the ground with the attack by making counter-trenches, particularly on the flanks, from which the attacking infantry positions could be enfiladed.*

The enfilade fire against the infantry positions may be delivered from rifles or machine guns, the latter being particularly adapted for this service.

The counter-trenches are protected by obstacles, such as crow's feet, land mines, etc.; but by day they are usually abandoned.

The defender must not be satisfied with pushing these counter-trenches a small distance out. If he is sufficiently strong numerically, he should extend them as much as possible, every position reached being a stepping-stone to another one.

The enemy will be forced to keep some batteries constantly employed shelling these counter-trenches, and this will take their fire away from the other main works of the defence. Moreover the existence of these counter-trenches compels him to advance with much greater precaution than would otherwise be necessary.

As already stated, minor sorties are effective means of disturbing the works of the attack.

REPULSE OF THE ASSAULT.

When the enemy has succeeded in pushing his trenches so close that he may be expected to begin his last parallel or assaulting position, everything possible must be done to prevent him carrying out this work; and his success must at any rate be very heavily bought.

This will at first be mainly the work of the flèche guns, and will be taken up by well-concealed gun and mortar batteries placed outside the works. (With frontal fire high-explosive shells with time fuses are the best; otherwise shrapnel). The emplacements for the last-named batteries must be prepared at the right time; but fire should not be prematurely opened, or the batteries will be discovered and annihilated. Enfilade fire from the counter-trenches may also have great effect, and hand-grenade mortars and bombs† will be of the utmost value.

The obstacles must be increased as much as possible by the addition of crow's feet, land mines, etc.

At night the foreground will be lighted by star shell, etc.

In expectation of the assault, the garrison must be kept in perfect readiness, and it is of the utmost importance that they should not become callous after several false alarms. (See para. 4, page 174).

Except in the case where uninterrupted observation of the enemy's

* This method was adopted frequently by the Russians at Sevastopol in 1854–55, being initiated by General Todleben; and since then has been officially taught by both Russians and French as a most effective measure. It was also adopted at Port Arthur.

† Heavy explosive charges fired as a fougasse and bursting on impact.

assaulting position can be carried out either from cupolas or by means of hyposcopic telescopes, great care must be taken that after every cessation of fire, *i.e.* when an assault may be anticipated, the whole garrison assume their fire stations, even though this may have to be done repeatedly to no purpose and with some casualties.

As soon as the enemy breaks from the assaulting position he must be overwhelmed with artillery and rifle fire, regardless of risks to the garrison. A portion of the less rapid firing guns would be detailed to operate against the reserves following the assaulting troops, but all the remaining guns would direct their fire against the assaulting troops themselves.

The reserves reinforce the garrisons of the intervals, and deliver counter-attacks at critical moments or when favourable opportunity offers.

The assault of a large fortress will be attended with very varying fortune. Even if the enemy succeeds in obtaining possession of a large portion of the front, it is always possible that he may be driven out by vigorous counter-attacks or by enfilade fire from the works as yet uncaptured; or he may at least be unable to make any further progress. (See footnote, page 164).

The same may be the case when the enemy, having broken through one of the intervals, has been able to advance against the interior of the fortress; for in this case his flanks will be exposed to attacks by the reserve. These attacks are rendered easier if the enemy is brought to a standstill by the fire of supporting positions in rear. (See para. 8, page 202).

Even works that have been successfully assaulted may be recaptured. Every effort should therefore be made to hold on to any portion, however small, as long as possible.*

When an assault has failed, the retreating enemy must be pursued by fire.

RESISTING THE ADVANCE BY SAP.

When the enemy, after several unsuccessful assaults or for other reasons, is induced to advance gradually by sapping† from the assaulting position against any particular work, he will usually be obliged to cease fire against that work in order not to endanger his own troops.

In this case, as the risk of surprise increases with the approach of the enemy, the defender must keep a portion of the garrison constantly manning the parapet. By day a few sentries will suffice, but by night one entire relief must be in readiness. Those guns which are still uninjured must of course be ready day and night for instant action. At night the *hangar geschütze*‡ and machine guns must be brought up. Every

* The fights round 203-Métre Hill at Port Arthur furnish examples.

† See last para., page 177.

‡ See footnote on page 188.

attempt of the enemy to break from cover to make an assault must be at once met by artillery fire.

As already stated, the engineering works, trenches, etc., of the attack are best destroyed or damaged by hand-grenades fired from mortars, or else by minor sorties.

If the attack resorts to mining, the defence will naturally countermine.

DEFENCE OF THE INTERIOR.

If the enemy has gained possession of the great part of the girdle of forts and it is impossible to drive him out, the resistance may still be continued a long time by occupying trenches previously prepared in rear, and finally by defending the enceinte of the fortress.

These trenches must be rapidly laid out and completed as soon as the front of attack is definitely known, and are either approximately parallel to the girdle line of forts or else radiating from the centre (see *Fig.* 10).

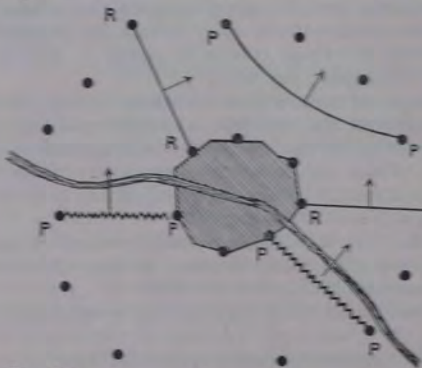


Fig 10.

P.P. = PARALLEL RETRENCHMENT.
R.R. = RADIAL RETRENCHMENT.

The first parallel retrenchment should be as close behind the line of forts as possible, but yet outside decisive range of the enemy's artillery position, and should as a rule rest on works which are still capable of stubborn resistance. The guns withdrawn from the intervals in front will be mounted in the parallel retrenchment.

A last parallel retrenchment can be formed behind the river flowing through the place, which acts as an obstacle while the enceinte itself forms a bridge head.

The radial retrenchments run from works still uncaptured to the centre of the fortress, and protect the flanks of the parallel retrenchments.

PART III.—THE MORE RAPID FORMS OF ATTACK AND DEFENCE.

1. THE ASSAULT BY SUPERIOR FORCE.

This has already been described in the Introduction. It is therefore only necessary to indicate the conditions under which this form of attack promises success, namely :—

(*a*). A weak or not very formidable garrison, whose resistance may probably be so weakened by heavy artillery fire that an assault may succeed forthwith without any extensive recourse to earthwork.

This might be the case with a garrison that had lost heart owing to the defeat or surrender of their main army, or that was composed of ill-disciplined and badly armed troops.

(*b*). An insufficient number of guns in the defence, or else insufficient protection for the guns so that they are easily put out of action.

(*c*). The works of the defence being either uncompleted, or else very weak, having ditches without flank defences or masonry revetments.

(*d*). Finally, an assault may succeed where the ground offers exceptionally good natural cover.

But the assault of a well-prepared work, even if old fashioned, which has a strong and valiant garrison, remains always a very risky and expensive undertaking.*

PRINCIPLES FOR ITS EXECUTION.

It is impossible to give a detailed description of a direct assault. Such assaults vary with the nature of the place and with the methods of the defence, and the differences may be extreme. At one time a direct assault will resemble a rapidly executed field operation ; at another it will approximate to a regular siege.

(1). A direct attack requires on the part of the attacking side great numerical superiority, valiant troops, special preparation, and simple and clear dispositions.

* Except Kars in 1877 modern history affords no example of the success of a direct assault. The assaults delivered at Port Arthur during the course of a regular siege were only successful on the west, and there only after repeated failures ;—*e.g.* attack on the advanced and semi-permanent works around 203-Mètre Hill—(1) assault, 19th to 24th August, (2) 17th to 22nd September, (3) 28th October—3rd November, (4) four attacks, one after the other, 26th November—6th December. It was only this last series that was rewarded with success, the way being prepared by the employment of the 11" howitzers and the losses amounting to 30,000 men.

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A plentiful supply of field and siege howitzers is of very great importance, as they are almost indispensable when attacking fortified works. Moreover, it is always advisable and often essential to bring up heavy mortars, as permanent works often cannot be breached by other means.*

(2). A complete and close investment is also very desirable.

(3). Frequent and bold reconnaissances are necessary, and the observers in balloons must be as quick as possible in discovering and communicating the information which is required before a final decision is arrived at and the first dispositions settled. It is possible by means of flags of truce to obtain a good deal of useful information regarding the sites of cantonments and the state of defence of inner lines.

Engineer and artillery officers must try to advance as early as possible right up to the line of works, in order to report on the nature, strength, and armament of the works and intervals.† More detailed information can only be obtained when the infantry have penetrated close to the line of forts.

(4). The main attack should be supported by a simultaneous attack on a neighbouring position, and in any case it is essential that false attacks should be made at several points.

If possible a direct storming of the works should be avoided; their fire-effect should be neutralized by fire. It is advisable to storm the intervals and then take the works in rear or in the flank.

The intervals in fact should always be chosen for attack when the forts on either flank are so designed that they cannot develop any very extensive fire over the intervals, or when they can be kept under by a heavy artillery fire, which with open works is not a very difficult matter.

On the other hand the assault may be delivered on those works of which the obstacles in front are weak and easily crossed, for when the works are captured the intervals between them are bound to be evacuated.

(5). The artillery must from the beginning be amply supplied with ammunition. Any shortage in this respect will delay the assault; this is most undesirable, since any loss of time adds to the difficulties of the investing infantry and permits the defender to strengthen his position.

* At Port Arthur even the 11" howitzers were not completely successful.

† Such reconnaissances have often been successfully accomplished. In 1757 an Austrian artillery officer, Capt. Barnkopp, after killing one of the hostile sentries in the sally-port, succeeded in penetrating into the interior of a Prussian fortress. In 1870 some N.C.O.s in the Bavarian engineers, in spite of being fired on, succeeded in reaching the gates of the fortress of Toul. Again in 1870 Capt. Ledebur of the Prussian engineers swam into the inundation between an advanced work and the main girdle at Strassburg and plumbed the depth.

The opening of fire should come as a surprise and every gun should be brought into action simultaneously. The fire in the first place must be directed against the most effective batteries of the defence, and then a concentrated fire must be brought to bear upon the whole of the selected front of attack.

The cantonments, the lines of communication, and the positions for the deployment of the reserves, should be incessantly shelled both before and during the assault, so that the reinforcement of any threatened point may be attended by severe losses.

In order to obtain better fire effect, especially as a preparation for the assault, it will often be advisable to take up a more advanced position for the artillery.

(6). The infantry attack will seldom, even under the most favourable circumstances, attain its object in one day, and as a rule several days will be required. It may, however, be started either by day or by night.

The advance by day compels the defender to show himself above the parapet, and therefore both the artillery and infantry fire of the attack will have greater effect; but the losses of the assaulting troops will also be more severe.

The advance by night will be attended with far less loss; but it allows the defender to get under cover from fire during the day, so at the moment of assault he may not be sufficiently shaken. Also by night it is very difficult to maintain the right direction; for this reason, even beyond the zone of the enemy's fire, it is advisable to undertake only direct advances.

If the ground offers any natural cover and the defender's fire is not particularly destructive, it is preferable to assault by day. If the contrary be the case, it will probably be necessary to advance by night, at any rate up to the assaulting position, and every endeavour must be made to prevent the defender from manning his parapets. During the advance the infantry, when necessary, must make hasty entrenchments and covered communications, and this will always be necessary when it is likely that they will have to remain for any time in a position. In future it will never be possible to advance against a position entirely in the open as used formerly to be done. In any case it will certainly be necessary to make an entrenched assaulting position.

(7). The assault will be best delivered at dawn (see para. 6, page 173). It will correspond with the assault already described under regular siege operations, except that the flank defences of ditches cannot be totally destroyed and often can only be dealt with by rifle fire. The provision of escalading ladders, etc., and the instruction of the troops in their use, must not be lost sight of.

Even direct assaults will not always be successful at the first attempt, and several assaults may have to be delivered.

DEFENSIVE MEASURES.

These will for the most part correspond with the defence against regular siege operations. The special points to be noted are as follows :—

(1). The defence armament and the mobile reserve must first engage the hostile batteries; but as soon as the infantry come within range most of the guns must be turned against them.

By night the foreground of the neighbouring works and intervals must be swept by fire directly the garrisons of those works or intervals have realized that they are being attacked. With this exception each gun should have a definite rôle assigned to it for night firing.

(2). The rifle fire will be mostly maintained from the trenches in the intervals, as the forts themselves may be so heavily shelled that it would involve enormous loss to man the parapets at all.

But, if the enemy breaks from the assaulting position to storm a fort or the neighbouring interval, the garrison of the fort must at once line the parapet and open fire, no matter how heavy their losses may be.

(3). The reserves must be constantly in readiness, particularly at night.

By day, when the condition of affairs can be easily grasped, it will not be difficult to dispose the reserves in the right place and at the right time.

By night, however, the enemy by means of feints may easily deceive the defence as to the real front of attack. Thus the reserves, especially the general reserve, may have to drive out the enemy after he has captured the works attacked. This task will be made much easier if "supporting positions" have been provided, the value of which was conclusively shown in the Russo-Japanese War.

(4). The greatest coolness and nerve is required in repulsing a direct assault. Every officer in particular must avoid hurry and excitement, as those under him will read from his countenance the extent of the danger. He must therefore by his calmness and absolute self-control inspire confidence in the breasts of all his subordinates. Shouting and running to and fro will only add to the confusion; but ready action at the critical moment may have most valuable results.

2. BOMBARDMENT.

By bombardment is understood the delivery of a very heavy artillery fire, principally against the heart of a fortress, in order to cause as much damage as possible and also such heavy losses to the garrison and civil inhabitants that the place is either surrendered forthwith or rendered incapable of resisting an attack.

Sometimes, however, the only object is to injure the defender's arsenals, depôts, or dockyards.

The conditions requisite for success are as follows :—

1. The fortress having its protecting line of forts too close in or else having no forts at all.
2. Lack of bomb-proof cover.
3. A faint-hearted garrison and a large civil population, who may exercise an evil influence on the commandant.

These conditions often produce themselves in any fortress as soon as the attack has broken through the line of forts.*

MODE OF EXECUTION.

Guns with long range and firing effective high-explosive shells are most suitable for bombardment (chiefly 9·6″ mortars and 6″ howitzers and some field howitzers); but even field guns are of assistance, particularly for shelling inflammable places, for numerous and extensive fires are the most effective means for ensuring success to a bombardment. It would, however, be useless to attempt the bombardment of a fortress with field artillery alone.

The bombardment should be directed against the opposing works, dockyards, arsenals, etc., and the town itself.

After the fortress has been invested as closely as possible, the batteries will be placed in scattered groups in well-covered positions all round it, and where necessary they will be protected by infantry in fortified positions in advance in order to guard against sorties.

The bombardment of buildings should be carried on mostly at night so as to increase the moral effect, and should be spread over the whole town so that the inhabitants may be deprived of rest.

It is therefore evident that to reduce an important place by bombardment requires an enormous expenditure of ammunition.†

* It is noteworthy that the old and ill-protected fortress of Strassburg, in spite of its population, withstood a bombardment, and also that little effect was produced by bombardment on Paris. (In those days, of course, the artillery was not so powerful as that of the present day). At Peronne, Soissons, Neu-Breisach, and Mezières the civil population induced the commandant to capitulate, while in Laôn the garrison itself insisted on surrender. At Pfalsburg the commandant was bold enough to disregard the pressure of the civil element.

† The bombardment of Verdun, 1870, failed owing to insufficient ammunition.

The bombardment of Paris lasted 3 weeks, and included about ¼ of the whole city, over which some 5,000 shells were fired. The result was 97 people killed and 278 wounded, and the moral effect was extremely small. According to the testimony of eye-witnesses the bombardment would have had no effect on the duration of the resistance, even if it had inflicted much heavier damages.

At Strassburg the bombardment lasted 4 nights, and some 12,000 shell were dropped into the town. The casualties of the garrison due to the bombardment are unknown, but of the civil population 40 were killed and about 160 wounded.

During the second bombardment of Sebastopol in 1855, to put one Russian *hors-de-combat* 2,000 lbs. of shot and shell were expended.

DEFENSIVE MEASURES.

A bombardment can only be met by artillery fire and sorties, both of which were successfully employed at Verdun.

Beyond this, the main point is to keep up the courage of the garrison, and to take every possible precaution to minimise the effects of the bombardment, which, as the above examples show, can be reduced to an almost negligible quantity.

The security of that portion of the garrison not on duty and of the civil population is best ensured by providing bomb-proof cover to cellars and by tunnelling into the earth. Where bomb-proof cover cannot be supplied splinter proofs will be of great value.

All windows exposed to fire should be bricked up, etc.

Conflagrations caused by the bombardment must be extinguished at once. Both civil and military buildings must be protected from fire as much as possible and a fortress fire brigade should be organised.*

3. COUP DE MAIN.

This is an attempt to force an entry into a fortified place before the enemy is prepared to offer any resistance.

It is only feasible against a place where no proper precautions are taken, or where the garrison is either disloyal or physically worn-out; and even in these circumstances it is only practicable against weak works ill provided with obstacles.

A surprise against closed works is generally effected by forcing an entrance through the gorge or by making a passage through the obstacles. The former is accomplished by artifice† or through the treachery of one of the garrison or by overwhelming the guard.‡

In attempting the surprise of a fortress with a girdle of forts, either the intervals, or one of the works, or even one of the sectional reserves, can be operated against.§

The attack is likely to succeed best at dawn, when the sentries are most in need of rest; but a thick mist or a storm of snow‖ or rain is also favourable for such attempts. The main conditions which lead to the success of a *coup de main* are as follows:—

* At Paris every outburst of fire was checked and extinguished almost at once.

† Fort Stanjević, near Cattaro, 1869.

‡ Cremona, 1707.

§ At Olmutz, 1866, the intervals could not be properly watched owing to the weakness of the garrison, and a Prussian party with a flag of truce penetrated into the heart of the fortress unobserved.

At Tikuza, 1849, General Urban penetrated the Hungarian outpost line and took the opposing commandant and several officers prisoners without a shot being fired.

‖ Surprise of the Mont Cenis forts by the Austrians, 1800.

(*a*). Strict secrecy as to the matter in hand.
(*b*). A simple plan of action, with previously arranged signals, and absolute silence during the operation.
(*c*). An accurate knowledge of the ground, obstacles, flank defences, and approaches.

The attack by surprise against an important fortress should be delivered from several sides, as it then offers more chances of success and if discovered compels the defender to split up his forces.

When the necessary reconnaissances have been made and the troops are all assembled in their appointed positions, an attempt will be made to capture the hostile outposts without giving the alarm and to obtain the countersign from them, upon which the general advance will be ordered.

No shot will be fired unless absolutely unavoidable, in which case all attempt at concealment must be abandoned and the troops must rush forward instantly to the assault.

In dealing with the walled ramparts inside an enceinte, when a portion of them has been successfully penetrated, some troops, preceded by engineers provided with explosives, should be directed against the nearest gate in order to open it for the main body.*

Vigilance on the part of sentries and picquets and a careful system of observation will always render a surprise impossible.

Further rules for the conduct of the defence cannot be laid down.

* At Cremona, 1707, and at Bergen-op-zoom, 1814, the parties who had penetrated through such ramparts did not blow open the gate and the enterprise failed.

PART IV.—THE FIGHT FOR BARRIER FORTS IN MOUNTAIN PASSES.

1. THE ATTACK.

In the attack of a position guarding a pass, time is of more importance than in attacking any other fortified place, because on the one side it is desired to open the closed line of communication as soon as possible, while on the other it is desired to hold and thoroughly fortify the position before reinforcements arrive.

To obtain a rapid success it is essential to open as soon as possible a very heavy artillery fire so as to secure superiority in this respect.

It must always be considered whether it is possible to break through the line of works by an infantry attack alone without elaborate artillery preparation. But even if this is possible, it will be of little value unless the works themselves can be captured; for, although infantry may break through, it will be impossible to pass convoys, even with large escorts, until the works are captured, and for this purpose artillery will usually be indispensable.

Under exceptional circumstances success may be obtained by surprise, and the possibility of this or any other shortened road to success should always be kept in view.

TROOPS REQUIRED.

The attacking army must be strong enough to carry out the attack on advantageous terms, and must from the beginning be well supplied with artillery and engineers.

The artillery park should be provided with the following ordnance :—(1). For bombarding the works, according to their strength, either heavy or medium guns. (With us against bombproof works 9·6″ mortars, against weaker works 6″ howitzers, the latter fired either directly or indirectly). (2). Against cupolas, effective medium flat trajectory guns, *e.g.* modern 4·7″ guns or, in default of these, 6″ guns, with high explosives. (3). Against semi-permanent works outside the forts, field howitzers; under certain circumstances light mortars may also prove useful. (See (*d*), page 153). The divisional artillery is chiefly employed against the mobile troops, against weaker works (*e.g.* blockhouses), and occasionally against the gorges of the forts.

The engineer park, in addition to tools, escalading ladders, etc., and explosives, must be well supplied with sap shields, empty sandbags, and corrugated iron for over-head cover.

Unusually heavy work will fall to the sappers, for, in addition to the usual works for the attack, the preparations for the artillery positions will be exceptionally difficult, the usual covered communications will be more numerous than on other occasions, and it may also be necessary to construct enveloping communications.

THE PRELIMINARY ADVANCE.

The approximate strength and position of the enemy must be ascertained and also the nature of the obstacles to be surmounted. This information will be obtained by cavalry and infantry patrols, who will also endeavour to cut the telegraph or telephone communications of the enemy.

The main body of the attack, with its parks and trains, will almost always be tied to one single road; but efforts must be made to get round the flanks and rear of the position by country roads and tracks, up which infantry and mountain guns can as a rule be taken.

The mobile force of the defence, which will as a rule be weak, at any rate at the beginning of operations, must now be pushed back; and the attack must obtain possession of any position from which this mobile force could hinder the preparations for the assault or the establishment of the heavy artillery. These measures often necessitate the occupation of positions well away on the flanks of the pass.

Those points also must be captured from which a good observation of fire can be made. Owing to the nature of the country, these will often lie far to one side or in advance of the artillery position. The enemy's observing stations must also be captured.

The camps and tents of the attacking force must be established out of range. Workshops and parks must, wherever possible, be located in valleys.

The preparatory work consists chiefly of making cover for the outposts and for the garrisons of those positions which, as already stated, must be occupied by the attack in order to prevent the defence from making use of them. Besides this shelters must be made for various purposes, communications improved, and telephone lines laid down. Finally arrangements for observation, generally from balloons, must not be overlooked.

The advanced posts will be pushed forward as far as possible towards the opposing works, and they will generally be divided into groups each with a separate reserve. The more important posts should be provided with machine guns.

If the defence has a large mobile force at its disposal, in addition to the garrisons of the works, the attack must first engage this force and separate it entirely from the works. The methods of securing this result belong more to the sphere of tactics than of fortification.

THE RÔLE OF THE ARTILLERY.

The artillery must come into action as soon as possible, that is to say immediately their position has been put into a defensive state and the necessary communications have been made.

Getting the heavy and medium guns into position may prove a very difficult task, especially when there are only a few suitable positions, all well known to the defender; and it may often happen that such positions with their approaches are always exposed to a heavy fire from the artillery of the defence. In such circumstances it may be impossible to bring up the guns over such exposed ground, and it will then be necessary at first to establish the guns at extreme ranges.

On the other hand, owing to especially favourable ground, either concealed from the defence or covered only by weak fire, the bringing up of the artillery into position may present no difficulties.

The tasks assigned to the artillery have been defined at the bottom of page 206.

It is of especial importance to silence the artillery of the defence, as until this is done there is little prospect of a successful advance. The attainment of this object will be much assisted by a bombardment from heavy howitzers. But guns with flat trajectory should be brought up as quickly as possible as they are more effective against the batteries and mountings. It must be remembered that it will be far more difficult to bring these guns into position than the howitzers, as owing to their flat trajectory they cannot easily be concealed behind natural cover.

It will seldom be possible to silence guns mounted on the flanks until the works themselves are captured.

The destruction of obstacles by artillery fire is just as difficult as in the case of those in front of a modern fortress, and this work must therefore be accomplished by the sappers. But the garrison of a barrier fort is more likely to be shaken than that of a fort in a girdle, as it is self-dependent and cannot expect relief. Moreover the artillery of the attack will be able to seize favourable opportunities for operating against the gorge, and will not be confronted with batteries lying outside the main works.

THE CLOSE ATTACK AND THE ASSAULT.

The close attack is characterised usually by the facilities for advance under natural cover offered by the spurs and gorges of the mountain range.

But these increased facilities are counterbalanced by the difficulty experienced in permanently occupying any position, for the ground is usually broken and rocky and connected trenches are very hard to construct.

Small detachments, however, will generally be able to advance close up to the works under cover of night. These will be able to send back accurate reports on the enemy's position, and will also protect the sappers at work destroying or surmounting the obstacles and flanking defences (see para. 4, page 172). These small detachments (skirmishers), companies with a few machine guns, will often have opportunities of firing on searchlights, etc.

The close attack is not entered on until the defence artillery has been considerably crippled. It may then be possible to advance during the night to such a distance that the assault may be delivered or at least a decisive struggle waged with the opposing mobile force stationed in the intervals.

If the mobile troops of the defence are vigorous and active in making sorties and in occupying the foreground as long as possible, a gradual advance as against a normal fortress and a long struggle for superiority of rifle fire may be necessary. The only way to avoid this, which is the most serious check the attack can meet with short of actual defeat, is to establish as early as possible an overwhelming superiority in artillery fire.

The assault will be carried out on the same lines as against a normal fortress. But the construction of an assaulting position or last parallel will often be omitted, owing to the stony ground, and a rough wall of stones or sandbags substituted.

The storming equipment should, if possible, be placed in naturally concealed positions close to the works to be assaulted.

The work of the sappers prior to the assault, which has already been described in previous sections, should be begun early. It must be remembered that repeated failures are to be expected and success can only be achieved when a decisive fire position has been won.

If the defence has no mobile force the attack will be much simplified.

The commencement of the close attack of a mountain position is absolutely conditional on the attainment of an overwhelming superiority of artillery fire; and in this it differs entirely from the close attack of a normal fortress, where such complete success is usually neither possible nor necessary.

2. THE DEFENCE.

The general conduct of the defence may be inferred from the remarks already made when considering the attack. Otherwise it resembles the defence of a normal fortress with the following exceptions:—

1. The garrison is generally thrown on its own resources at the commencement of hostilities. It must therefore renounce all ideas

of offensive measures, which will be left to the mobile force on its arrival to support the garrison.

2. The obstruction of the establishment of the enemy's artillery becomes of increased importance.

3. The struggle with the opposing batteries is more difficult to maintain as the attack has generally a more marked superiority in this respect. But it must be carried on with the utmost energy and skill, in order to delay the commencement of the close attack as long as possible.

Particular attention should be paid to the guns with flat trajectory, which will be brought into action against the batteries of the defence.

4. Alertness is especially necessary to frustrate attempts at surprise and the attempts of the opposing sappers to destroy the obstacles.

5. The occupation of special points in the foreground is only possible when a mobile force is available.

If only a few mobile troops are available, an attempt should always be made to push forward by night small detachments with machine guns.

6. If the works are weakly held, owing to lack of troops, land mines and hand grenades will be found of great value.

7. The capability and energy of the Commander is of special importance when holding a barrier fort.

8. Under no circumstances should external troops be permitted to take refuge in the defence works.

PART V.—THE FIGHT FOR COAST DEFENCE WORKS.

1. THE ATTACK.

Coast defence works may be attacked either from the land side or from the sea, or from both simultaneously.

The attack from the land side will follow the same lines as the attack on a normal fortress, and need not be further described.

The attack by sea will be carried out by the navy,* and therefore will only be examined here so far as to give a general idea of the lines on which it will be planned.

The main forms of attack are Blockade, Bombardment, and Assault from the Sea.

BLOCKADE.

For this purpose the fleet will take up a position in front of the harbour, beyond the range of the guns in the works, and prevent any ship escaping from the harbour into the open sea.

The smaller craft (torpedo boats, etc.) will endeavour to discover the movements and intentions of the hostile fleet in the harbour, so that the battleships and cruisers can engage with them when a favourable opportunity offers.

At the same time measures must be taken against an attack from the open sea or an attempt to raise the blockade.

A blockade ties a large number of ships to one place, as the blockading fleet must be at least equal to the fleet shut up in the harbour; and therefore it is not a form of attack which can be commended unless the attacking force is too weak to deliver an assault and a bombardment is for some reason impracticable. But it may well form a prelude to either of the latter forms of attack, or it may be usefully adopted in conjunction with an attack by land.†

* The best book on this subject is *Der Küstenkrieg*, by Major Siegmund Mielichhofer, Vienna, 1903.

† In order to maintain a blockade with the minimum number of ships, the Japanese successfully adopted the plan of blocking the mouth of the harbour entrance with floating mines and sunken ships loaded with dynamite.

It was owing to one of these mines that the attempt of the Russian fleet to break out of the harbour failed, when the *Petropavlovsk*, with the most distinguished Russian Admiral, Makarof, on board, was destroyed by a mine.

By means of the sunken ships the entrance of the harbour was blocked to large vessels up to the 2nd May.

BOMBARDMENT.

The chief object of bombardment is to destroy the enemy's ships in the harbour and also the docks and harbour works.

For this purpose the fleet must anchor outside the range of the guns in the coast batteries, or else must be protected from them by an island.

The minimum distance will therefore be about 10,000 yards and the maximum 15,000 yards, beyond which the bombardment will not be effective.

Even at the above ranges accuracy of fire will be difficult to attain; and therefore, in view of the limited amount of ammunition carried, a bombardment is not a very advantageous form of attack.

There is in fact no actual example of a successful bombardment.*

ASSAULT FROM THE SEA.

This will be preceded by a blockade of the harbour, and will then proceed as follows:—

1. Removal of the mines in the outer harbour.
2. Reconnaissance of the coast defence works.
3. Artillery duel with the coast batteries, with a view to silencing them.
4. Removal of inner minefield.
5. Forcing the harbour entrance.
6. Battle with the fleet in the harbour.
7. Landing of troops to seize the coast defence works.

The removal of the outer minefield is a very difficult task, which cannot be executed without heavy losses. There are several methods of carrying out the work;—

(*a*). Searching with submarines, and either blowing up the mines or bringing them to the surface.
(*b*). Sweeping with torpedo boats connected by cables.
(*c*). Setting old ships adrift across the minefield.

For the artillery duel with the coast batteries the ships must approach very close (from 3,000 to 5,000 yards) in order to have any chance of success. In order not to be annihilated by the accurate fire of the guns in the batteries at this decisive range the ships must keep under way the whole time. This however will affect the accuracy of the ships' fire more than that of the batteries.

A ship presents a very easy target at such ranges. Moreover, the upper deck is not armoured; and therefore the heavy howitzers

* The destruction of the Russian fleet in Port Arthur was entirely the work of the land batteries (see footnote, page 151).

(modern 11" coast defence howitzers), heavy mortars (8·5" coast defence mortars), and high-angle fire guns (11" and 12" coast defence guns) of the defence will do great damage. The armoured deck can, according to its strength, be destroyed by the heavy howitzers at a range of from 3,000 to 8,000 yards. The armoured belt can be destroyed by the heavy guns at a range of 3,000 yards. Unprotected ships can of course be destroyed by medium ordnance (6" coast defence guns and howitzers) at greater distances; and torpedo boats can be effectively dealt with by light quick-firers.

The ships in fact are at such a disadvantage that success can only be obtained by a vast superiority in the number and weight of their guns.*

During the artillery duel the removal of the inner minefield must be accomplished; and also the destruction or removal of booms or other obstacles, which will seldom be possible without the loss of one or two ships.

In forcing the entrance to a harbour the submarines will generally lead the way, followed by torpedo boats and then by the battleships, the cruisers bringing up the rear.†

After this the battle with the hostile fleet will take place; and finally troops will be landed to capture the coast defence works, an undertaking by no means easy.

It is obvious that an assault by sea is a very difficult enterprise, and its success is very problematical.

When one further considers the poor results obtained by bombardment, the conclusion is forced on us that the best way to capture modern coast defence works and to destroy a hostile fleet in its own harbour is by an attack from the land side.

2. THE DEFENCE.

Every endeavour must be made in peace time to have the defences in immediate readiness for hostilities, as the enemy's ships may make their appearance simultaneously with the declaration of war.‡

* At Cuba, 1898, the Americans expended £375,000 worth of ammunition against Fort Morro and its smooth bore guns, and damaged one platform.

At Lissa in 1866 the attacking Italian fleet expended 2,400,000 rounds against the obsolete fortress, and so 44,000 rounds were used in putting one Austrian soldier out of action. The failure of the attack was entirely attributable to the heroism of the Austro-Hungarian artillery, consisting of 2 coast artillery companies whose losses were 13 killed and 57 wounded.

† With badly defended harbours a surprise forcing can take place without any previous artillery engagement.

‡ An example of this is given by the Japanese torpedo-boat attack on the Russian fleet anchored at Port Arthur on 8th February, 1904, when 3 battleships were stranded.

Furthermore, during the whole course of the defence the efficiency of every arm, guns, range finders, and search lights*, must be constantly maintained.

In coast defence the main rôle falls to the artillery, but they can be ably seconded by the navy.

The chief duty of the infantry is to patrol the coast and co-operate in the repulse of landing parties.

The defence of the land front corresponds to the defence of a land fortress.

The first and most important duty of the coast batteries is to keep the hostile fleet at a distance. To effect this, fire should be directed in the first instance on the battleships, not only by the heavy coast defence howitzers and mortars but also by the more accurate heavy coast defence guns. This artillery fire should keep the blockade at a distance, afford a manœuvring area to the ships of the defence, and also prevent the possibility of a bombardment.†

If the hostile fleet decide to make an attack, the guns of medium calibre will engage the torpedo boats and other small vessels which come in either to reconnoitre or to remove the outer minefield; and the light Q.F. guns will come to their assistance as soon as the range admits.

The heavy guns, howitzers, and mortars will be employed against the battleships and cruisers. At long ranges (over 3,500 yards) the guns will fire explosive shell, but at short ranges (under 3,500 yards) armour-piercing projectiles will be used.

The medium and light guns will be employed against those ships which have succeeded in getting within short range.

As already stated, it will hardly be possible for the ships to silence the batteries; yet it must not be supposed that for this reason no attempt to force the entrance to the harbour will be made. The hostile ships must therefore be kept constantly under fire, especially the leading ships.

The *Navy* may co-operate in the repulse of an attack in the following way, apart from any independent scheme undertaken on a large scale:—The submarines and torpedo craft may make excursions during the course of the blockade; they may patrol the minefields and oppose any attempt to remove the mines; they may replace mines cut adrift. The larger ships will support the coast artillery with their heavy guns, and will engage with the hostile fleet when it attempts to enter the harbour.

The *repulse of landing parties* is dependent on a careful watch being

* Search lights play a very important part in coast defence. They not only help to discover hostile ships, but increase the difficulties of their navigation.

† At Port Arthur the Japanese fleet, with the exception of torpedo boats, never ventured within range of the Russian guns.

kept on the stretches of the coast, so that no attempt at surprise can be successful. In addition to this, bodies of mobile troops with field guns must be established at suitable centres, so as to be able to hasten to the threatened point on the receipt of news of an attempt to land. These troops must be first employed in preventing the actual disembarkation of the landing parties; and in this they can seldom expect to have any support from their coast batteries, as the landing place will probably be so selected that the guns in the works can bring no fire to bear upon it.

If the disembarkation cannot be prevented, the mobile troops will retire towards the coast works, but in such a way as not to mask their fire.

In a landing made after the fleet has forced an entrance into the harbour there will probably be no attempt at surprise; therefore, unless a simultaneous attack is delivered from the land side, it will not be difficult to assemble sufficient troops at the required points in time to repulse the landing.

In conclusion it may be added that a modern harbour has nothing to fear from an attack by sea so long as it is kept in a state of preparedness and efficiency.

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FORTRESSES AND MILITARY ENGINEERING IN RECENT LITERATURE.

HEFT 43. MITTEILUNGEN DES INGENIEUR-KOMITEES.

TRANSLATED BY CAPT. F. A. BUZZARD, R.F.A.

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PREFACE.

THE study of professional literature constitutes, without doubt, a real means of improving the scientific education and at the same time the practical efficiency of our Officers. Unfortunately, however, their military duties often leave them no time to undertake very thorough study in this direction.

The Engineer Committee therefore intends to issue publications which will give their readers at least a general knowledge of the most noteworthy additions to literature dealing with Fortresses and Military Engineering. It is hoped to stimulate the study of various questions; while at the same time suitable sources of information will be given on matters affecting scientific theoretical work and practical undertakings.

These publications will be of use not only to Engineer and Pioneer officers, but also to officers of other arms who are anxious to extend the scope of their knowledge, especially as official instructions and technical details have been generally omitted.

As it is intended that the present number should form the basis for future issues which will be published from time to time, it has been necessary to go back rather far into the past.

Owing to the large amount of literature which has had to be referred to, very little space has been available for discussing individual works, and no claim can be made that this is a full summary. The Committee will, however, be glad to be informed of any omissions; these will be corrected in future numbers, which will go into greater detail.

THE ENGINEER COMMITTEE.

BERLIN.
Autumn, 1906.

It may be noted here that the collection of the Official Regulations and Handbooks on Engineer and Pioneer matters for all foreign armies has recently been completed as far as possible in the libraries of the Inspector General's Department (Generalinspektion) and the Engineer Committee. The War Minister and the General Staff have assisted in this, and the collection will be kept up to date.

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List of Abbreviations.

PART III.—IMPROVISED FORTIFICATION, FIELD FORTIFICATION, AND OTHER TECHNICAL ENGINEER WORK.

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COAST WARFARE.

PART V.—FORTRESS WARFARE. OPERATIONS IN CONNECTION WITH FORTIFIED POSITIONS AND RIVERS.

List of Abbreviations.

Internat. Rev. :—Internationale Revue über die gesamten Armeen und Flotten.
Jahrb. für A. und M. :—Jahrbucher für die deutsche Armee und Marine.
J. des S.M. :—Journal des Sciences Militaires.
Jour. M.S.I. :—Journal of the Military Service Institution.
Jour. R.U.S.I. :—Journal of the Royal United Service Institution.
K.Z. :—Kriegstechnische Zeitschrift.
Löbell :—von Löbell's Jahresberichte über die Veränderungen und Fortschritte im Militärwesen.
Mar. Rund. :—Marine Rundschau.
Mitt. A.-und G. :—Mitteilungen über Gegenstände des Artillerie-und Geniewesens.
Mitt. des I.-K. :—Mitteilungen des Ingenieur-Komitees.
Mitt. Seewesens :—Mitteilungen aus dem Gebiete des Seewesens.
M.W. :—Militär Wochenblatt.
N.M.B. :—Neue militärische Blätter.
Organ der m-wiss. V. :—Organ der militär-wissenschaftlichen Vereine.
R.E.J. :—The Royal Engineers Journal.
Rev. de l'A. Belge :—Revue de l'Armée Belge.
Rev. du G.M. :—Revue du Génie Militaire.
Rev. Mil. des A.E. :—Revue Militaire des Armées Étrangères.
Riv. A. e G. :—Rivista di Artiglieria e Genio.
Russ. Ing. J. :—Russisches Ingenieur Journal.
Schweiz. Zeit. für A. und G. :—Schweizerische Zeitschrift für Artillerie und Genie.
Schweiz. mil. Zeit. :—Allgemeine schweizerische Militärzeitung.
Streffleur :—Österreichische militärische Zeitschrift (Streffleur's).
Überall :—Überall zeitschrift für Armee und Marine.

NOTE.

No distinguishing mark is placed against the names of books, etc., which are to be found in the Library of the Inspector General of the Corps of Engineers and Pioneers. The letters (B.I.K.) are placed after the names of works contained in the Library of the Engineer Committee.

(Titles of books and of periodicals are printed in italics; titles of articles in periodicals are in ordinary type with inverted commas.

The books and articles referred to in the text are re-numbered in each Part.—*Edr., R.E.P.P.*).

FORTRESSES AND MILITARY ENGINEERING IN RECENT LITERATURE.

PART I.

THE DEFENCE AND FORTIFICATION OF A COUNTRY.

A.—The Value of Fortifications.

Next to the Field Army and the Navy, Fortresses constitute the most important means of carrying on War. It is only from a clear conception of the rôle of Fortresses in War that the true principles to govern their disposition can be arrived at.

Von der Goltz (1) deals with the objects for which fortresses are required. Amongst these he gives the securing of important localities, the blocking of lines of inter-communication, the protection of the capital, the command of river crossings, and the securing of a tract of country by fortifying the most important town within it. On the other hand he does not agree that they should form points of support for the deployment, bases from which to advance, and the like, or that they "should take a passive part in all the movements of the army."

The same author (2) says that a leader may well be wrecked on the sunken rocks which will lie in his course, should he use a Fortress as a point of support and a pivot for the operations of his army.

In this work he recommends Fortresses particularly for securing a province situated at a distance from the theatre of war, as protection for the flanks, and as strong points the mastering of which would weaken an enemy and diminish the forces with which he could continue his advance.

Leithner (3) recommends that space for deployment should be secured by fortifying points on frontier rivers and the junctions of passes leading over frontier ranges. He is also in favour of

(1) *Das Volk in Waffen.* Berlin, 1899.
(2) *Krieg und Heerführung.* Berlin, 1901.
(3) "Studie über Reichsbefestigung": *Mitt. A.-und G.*, 1893.

strengthening the base by means of fortification, effecting this by works covering main lines of communication.

In (4) Brialmont advocates fortifications for the security of the capital and of the principal junctions, as well as of an important place in a remote province. He also speaks of the 'régions fortifiées' previously suggested by Willisen, and wishes these to be established on, or upon the flank of, the probable line of advance of the enemy. He also wants them on any other possible lines of invasion as well. These 'régions fortifiées' are dealt with at greater length by the same author in (5), in which work he discusses also the value of fortresses. He particularly favours the fortification of capitals, provided that these are situated in important strategical positions, and the construction of works which will afford frontal and flank protection during the assembling of an army. Fortresses should also protect the larger depôts of supply and, in the form of bridge-heads, ensure a safe line of retreat to one's own army and provide for it the possibility of resuming the offensive. Brialmont goes thoroughly into the question of establishing and organising 'régions fortifiées,' and at the end of his work gives suggestions as to how this method of fortification might be applied in France, Germany, Austria-Hungary, Italy, Russia, and Roumania.

Welitschko (6) remarks that Russia possesses a 'région fortifiée' of the above-mentioned kind, meaning the fortified radius of Warsaw. He considers that the main factors in the defence of a country are its mobile forces—Army and Fleet—and its Fortresses. To the latter he assigns a number of duties, among which may here be mentioned their acting as points of support for the operations of the Army and the Fleet, the protection of the Army during its deployment, and the command of the Lines of Operation.

(7) contains reflections upon the uses of fortresses. The latter may be isolated or in groups—régions fortifiées—and should be used as points of support for armies operating near them, to protect depôts of supply, etc.

In (8) Stavenhagen considers in great detail the objects and natures of fortresses and their importance and influence.

In (9) Schroeter demonstrates the importance of Fortresses very completely. With the aid of an instructive example he illustrates

(4) *La Défense des États et la Fortification à la fin du XIX. Siècle.* Brussels, 1895.

(5) *Les Régions Fortifiées: Leur application à la Défense de plusieurs États Européens.* Brussels, 1890.

(6) "Fortifikatorische Verstärkung der Staaten und Festungsbau": *Russ. Ing. J.*, 1902 and 1903.

(7) *Nouveau Manuel de Fortification Permanente.* Paris, 1895.

(8) *Grundriss der Befestigungslehre.* Berlin, 1900.

(9) *Das Festung in der heutigen Kriegführung. Part I.* Berlin, 1903.

their value and their influence upon Field Operations. He then proceeds to establish the soundness of the conclusions arrived at, which all deal with the larger issues of warfare, by reference to a number of examples taken from military history. These show how fortresses generally mask, protect, and facilitate the movements of one's own forces; how, when situated near the frontier, they assist the strategical deployment; and how, when in rear or on the flank of an advancing opponent, they serve to engross the attention of a considerable proportion of his strength.

Rieger also (10) deals with the functions of fortresses in the conduct of the larger operations of war. They should increase the mobility and freedom of manœuvre of the army by dominating the most important junctions and guarding the chief depôts. When necessary they may also serve as places of refuge. He quotes in support of his views a number of well-known military writers, and also lays stress upon the moral effect of fortresses. As an example of this he points out that the presence of a fortress had a decided influence upon the action of the Allies in 1854 after the battle of the Alma.

In (11) Kuk points out how difficult it is, when designing a scheme of fortification, to guard against hostile criticism; for the latter never breaks out until a crisis arises, when the grounds upon which the scheme was founded may have lost their importance owing to changes in the political situation, the introduction of new weapons, or other reasons. He therefore thinks that most attention should be paid to those considerations which will always be advantageous to any defensive position, namely, open country in front of and between the works, good fire positions, and good communications towards the rear. He considers that fortresses may be used with advantage for the protection of important localities, the strengthening of the offensive, and as supports to field operations.

Tilschkert (12) discusses the functions of Fortresses almost entirely from the point of view of their co-operation with the Field Army. Meyer (13) wishes to see this co-operation restricted to a very few occasions. In (14) Welitschko distinguishes between manœuvre fortresses, barrier fortresses, and coast defences. He deals most with the tasks which might fall to the first of these.

(10) *Urteile und Ansichten über Nutzen und Gebrauch von beständigen und Stegreifbefestigungen.* Vienna, 1888.
(11) "Wozu braucht man Festungen?": *Organ der m-wiss. V.*, 1898.
(12) "Einzelfestung, Festungsreihen an Verteidigungs-und Operationslinien und befestigte Operationsräume": *ibid.*, 1898.
(13) *Zur Frage der Landesbefestigung.* Berlin, 1898.
(14) "Festungen und Festungsbahnen": *Russ. Ing. J.*, 1898. Summarised in *Mitt. A.-und G.*, 1899.

Leithner starts with the fundamental idea of "Few, but strong, fortresses" when he discusses their rôle in (15). He is in favour of chains of forts, which will fulfil several objects at the same time, and barrier fortresses, which will generally serve only one purpose, that of barring lines of communication.

Supported by the experiences of 1870–71, Heyde (16) discusses the question of how the fortifications of a Great Power should be disposed. He is almost exclusively in favour of fortresses in conjunction with girdles of forts, and thinks that these should be placed at intervals of some 100 to 150 kilomètres. Behind these he would have, in second and third line, a few great places of arms, which would act as rallying points and supports to a beaten army, and cause the enemy to weaken his forces by having to detach troops for the purpose of investing them.

In (17) Toilow investigates the objects which the fortresses of the Empire fulfil in defensive and offensive warfare. In the latter the system of fortification adopted should protect the area of strategical deployment, secure the advance from this area, and assist in the protection of those parts of the country which are not covered by the advance of the Field Army.

In (18) Gundelach quotes Napoleon's views on fortresses, according to which they should afford to the weaker side a favourable field of operations both for attack and defence, and under certain circumstances enable it to gain time pending the arrival of reinforcements. The author calls attention to the great influence of the French fortresses in 1870–71, neglected though they were. Even after the catastrophe of Sedan the resistance offered by them compelled the enemy to fight twelve battles and to capture twenty fortified places. They carried out most completely Napoleon's idea of gaining time. We know that this gaining time, which rendered it ever more likely that Powers which had hitherto remained neutral would intervene in the struggle, caused the German military leaders and diplomatists many an anxious hour. The smaller French fortresses were a real assistance to the Levée en Masse in 1870–71, and Gundelach therefore considers that in the case of Germany also the fortresses should not be situated only on the frontiers.

(19), by Schroeter, besides being an appreciation of the Field

(15) "Die Beständige Befestigung und der Festungskrieg": Vol. 3. *Neueste Anschauungen.* Vienna, 1899.

(16) *Landesbefestigung.* Rathenow, 1886.

(17) *Studie über Ländesbefestigung.* Hanover, 1894.

(18) *Festung und Feldarmee im Kriege, 1870–71.* Berlin, 1902.

(19) *Die Bedeutung der Festungen in der grossen Kriegführung, auf Grundlage der Moltkeschen Operationsentwürfe für die Kriege mit Dänemark, Österreich, und Frankreich.* Berlin, 1904.

Marshal's fortress strategy, contains much that is instructive and suggestive in connection with the value of fortification at the present day in the conduct of war on a large scale. The passages in *Moltke's militärische Korrespondenz* which bear upon this subject are given word for word or summarised, whilst brief descriptions are given of the various fortresses as they existed at the period dealt with. Annexed to the principal sections of the book are studies in greater detail of the functions allotted by Moltke to the different fortresses; and, in conclusion, the many ways in which, according to the plans, it was foreseen that the fortresses might be used are summarised.

Whilst discussing the same book in (20), Frobenius expresses the opinion that the Field Marshal in no way under-rated the importance of fortresses in the conduct of war, but may perhaps have erred in the opposite direction.

(21) describes briefly the course of the fighting round the different fortresses during the period in question. It does not, however, dwell upon the tactical questions of fortress warfare itself, but deals with the influence of fortresses on the general course of a war. It shows how Frederick the Great, in contradiction of the views previously held, adopted the principle that fortresses, notwithstanding their utility for keeping control of a limited area of country, were in fact only a means of support to the field operations. It shows too how Napoleon looked upon a fortress merely as one of many aids to success in war; how well he understood the art of making the best use of fortresses; and how they served to increase his mobility when on the defensive and to afford him protection in rear and on the flanks. Attention is called to the use which Radetsky and the Archduke Albrecht made of the Venetian Quadrilateral; and to the good service which Paris, as a great central fortress, rendered the French in 1870–71.

Finally we may here call attention to (22) and (23).

B.—RAILWAYS AND FORTIFICATIONS.

The fortification of important centres of communication, these being mainly railway junctions, is recommended by most of the above-mentioned writers.

(20) "Moltke's Festungsstrategie," *Jahrb. für A. und M.*, 1904.

(21) *Die Festung in den Kriegen Napoleons und der Neuzeit. Studien zur Kriegsgeschichte und Taktik*, herausgegeben von Grossen Generalstabe. Kriegsgeschichtliche Abteilung I. Vol. 4. Berlin, 1905.

(22) "Napoleon, Moltke, und die Festung," by Frobenius: *Jahrb. für A. und M.*, 1906. Also published separately in Berlin, 1906.

(23) *Bedeutung von Befestigungen in der Kriegführung Napoleons*, by Wlaschutz. Vienna, 1905.

There can be no doubt about the importance of railways in war; and there are those who go so far as to say that an army does not need fortified supply depôts, for all its requirements can be brought by rail from distant portions of its own country. On the other hand Leithner (15) considers that the railways will be fully occupied in the transportation of troops, especially during the days of the strategical deployment, and that they will also be very liable to be destroyed. He does not therefore look upon the fortification of places of supply as unnecessary.

Meyer (13) deals very thoroughly with the railways upon which the maintenance of the offensive impulse depends. He is, for instance, in favour of rendering secure as many lines of rail over the Rhine as the field army, operating in France, would require for communication with its various depôts.

According to this author, fortresses arrest the forward march of an invader and facilitate the re-conquest of any country which may have been lost. Meyer mentions the following as suitable objects for the construction of fortresses;—permanent command of one's own country, especially of its railways, and the possibility of rapidly recovering any area of one's country which may be lost. The book in question also refers to the moral value of fortifications, taking as an example those of Metz, which are the visible sign of a determination of holding on to what has once been won.

In (24) Pierron concerns himself with the importance of the Lines of Communication; with the whole question of supply in its widest sense, and the influence of this question upon the fighting capacity of the Army and the defence of the country; and with the services which the art of fortification is able to render in the matter of securing these lines of communication, especially when applied in the form of field and temporary works.

In Appendix (*b*) of the work (21) it is remarked, when discussing Napoleon's directions for the fortification of posts on the line of communications, that modern armies, owing to their larger numbers and great requirements in the way of ammunition, are far more dependent on their communications than were the armies of those days.

Welitschko (6) warns us against adopting a too one-sided opinion of the value of railways. He says that the successful defence of the country in the future will not depend upon a more or less developed network of railways commanded by fortresses, but upon the manner in which the leaders of the army make use of these railways and fortifications.

(24) *Stratégie et Grande Tactique d'après l'Expérience des Dernières Guerres.* Paris, 1896.

C.—THE QUESTION OF FORTIFICATION IN THE VARIOUS STATES.

(*a*). GENERAL.

(25) shows us the arrangement of the fortifications in the various states of Europe.

The object and arrangement of fortifications within certain areas are dealt with by quite an array of writers. Amongst these may be mentioned :—Löbell's *Jahresberichte*, which deals with the fortress question in all countries; Schröter (9), who gives short descriptions and sketches of the defences of Germany, Russia, France, Belgium, Austria-Hungary, Roumania, The Netherlands, and Switzerland; *Die Heere und Flotten der Gegenwart*, where again the fortifications of the different States are dealt with; as well as the periodicals *Internat. Rev.*, *Jahrb. für A. und M.*, *Mitt. A. und G.*, *Streffleur* and *K.Z.*

Toilow (17) discusses the Land Fortifications of the various States of Europe (except the Balkan and Scandinavian Peninsulas), with special regard to geographical considerations.

(*b*). THE BALKAN PENINSULA.

Information as to the fortifications of Turkey is to be found in (26) and (27).

The defences of Roumania are dealt with in (28), those of Greece in (29).

Information upon the fortress question in Bulgaria is to be found in (30) and (31).

(*c*). BELGIUM.

(32) and (33) deal with Belgium.

(*d*). FRANCE.

The article (34) treats of the situation on the western frontier of Germany. With reference to the German fortifications, it is pointed out how, after 1871, the political situation and the favourable network of railways caused the idea of offensive action against France

(25) Karte zu den *Mitt. des I.-K.*, No. 38. Berlin, 1905.
(26) *Darf Russland einen Angriff auf den Bosporus wagen?* Vienna, 1892.
(27) "Die militärische Lage in der Turkei:" *Internat. Rev.*, 1903, Beiheft 40.
(28) "Die Befestigung Roumaniens": *Russ. Ing. J.*, 1894.
(29) "Die Befestigungen Griechenlands," by Kurchhoff: *N.M.B.*, 1906.
(30) *Internat. Rev.*, 1903, p. 409.
(31) *M.W.*, 1904, p. 105.
(32) "Die Landesbefestigung Belgiens": *K.Z.*, 1904.
(33) "Die belgischen Festungen": *N.M.B.*, 1904.
(34) "Der Kriegsschauplatz zwischen dem Rhein und der Seine und die Hauptaufgaben seiner Befestigungen": *Mitt. A.-und G.*, 1904. Also published separately in Vienna, 1904.

to be adopted as the best strategy; and how the authorities were satisfied to maintain only the fortresses on the Rhine, which could in case of need cover the strategical deployment.

Subsequent changes in the conditions of international politics gave rise to the possibility of a war involving both frontiers. As this might have led to the adoption of a defensive attitude against France, it was found advisable to build more fortresses beyond the line of the Rhine, to protect Lorraine and the Palatinate and to serve as a bulwark against a French invasion. On the other hand France, in 1870-71, wished to form with her fortifications a great defensive barrier ('rideau défensif') to assist the Field Army in blocking the lines of approach to Paris, and finally to turn the Capital itself into an impregnable stronghold.

We are made acquainted also with the defence organisation of France by the Manual mentioned above (7). In (35) the political and geographical conditions of the frontier are discussed, together with those railways which affect the question.

The following deal with the fortifications of France :—(36), in which Kuchinka enumerates all the fortresses of France in a table, (37), (38), (39), and (40) where the last-mentioned book is discussed.

From the point of view of military geography, the two following articles are worth noting :—(41), in which the Plateau in question is described particularly with regard to a possible attack from the north-east or east, and (42).

In conclusion we may mention (43), by Immanuel.

(*e*). ITALY.

See also under (*g*).

Information regarding the Venetian Plain is to be found in (44). The fortifications of Italy are discussed in great detail by Rocchi in

(35) *Die Befestigung und Verteidigung der deutsch-französischen Grenze*, by v. Donat. Berlin, 1894.
(36) "Neue Einteilung der Befestigungen Frankreichs": *Mitt. A.-und G.*, 1902.
(37) *Classement et Déclassement des Places de Guerre. Servitudes Défensives.* Paris, 1899.
(38) Chr. Klar's *Die Befestigungen an der französisch-deutschen Grenze.* Vienna, 1892.
(39) Tenot's *Les nouvelles Défenses de la France: La Frontière, 1870—1892.* Bordeaux, Paris, 1893.
(40) "La Frontière": *Jahrb. für A. und M.*, 1893, p. 208.
(41) "Le Morvan dans la Défense de la France": *J. des S.M.*, 1902 and 1903.
(42) "Frankreichs Kanal-politik seit 1879 in ihrer militärischen Bedeutung," by Haehling v. Lanzenauer: *M. W.*, 1905.
(43) "Die Sperrbefestigungen der französischen Ostgrenze im Lichte der neuesten Beurteilung": *K.Z.*, 1905.
(44) "Die italienisches grossen Manöver, 1903": *M. W.*, 1903.

(45), a very complete work, which also includes in its scope the main principles of permanent fortification, its technical details, and the attack and defence of fortresses. We may also note (46) and (47).

(*f*). THE NETHERLANDS.

Information is contained in (48).

(*g*). AUSTRIA-HUNGARY.

Two papers by Frobenius, (49) and (50), as also the article (51), deal with the defences of Austria-Hungary.

(*h*). THE PYRENEAN PENINSULA.

See (52) and (53).

(*i*). RUSSIA.

Russia is very well supplied with literature connected with military geography. We may note here the following :—(54), (55), in which the area of deployment, the railways, and the fortifications of Galicia are discussed, (56), (57), and (58).

(59) is written by a German officer, who handles the question concisely and clearly, especially in its strategical aspect.

Several articles in (60) afford information as to the forcing of the line of the Narew and the provisional construction of Zegrze.

(45) *Traccia per lo Studio della Fortificazione Permanente*. Turin, 1902. Extract in *Mitt. A.-und G.*, 1903, "Italienische Ansichten über die beständige Befestigung und Festungskrieg."

(46) Zanotti's *Fortificazione Permanente*.

(47) *Manale di Organica Militare*, Section 4. Turin, 1901.

(48) *Onze Defensie*, by Scherer. The Hague, 1893.

(49) "Das Landesverteidigungssystem Galiziens": *Internat. Rev.*, 1895 and 1896.

(50) "Das Landesverteidungssystem Tirols": *Archiv. für A.-und Ing. Offiziere*, 1895.

(51) "Die Grenzbefestigungen zwischen Italiens und Österreich": *Internat. Rev.*, 1906. Beiheft 72.

(52) "Die Pyrenäen": *N.M.B.*, 1903.

(53) "Überblick über den Stand der Befestigungen der pyrenäischen Halbinsel": *Mitt. A.-und G.*, 1894.

(54) "Das russische Kriegstheater," by St. Sarkotio: *Streffleur*, 1894.

(55) *Dei vordere Kriegsschauplats Österreichungarns*, by Christani. Petersburg, 1902. Extract under title "Galizien und Bukowina als Kriegsschauplatz in russischer Beleuchtung."

(56) "Die Verteidigungsfähigkeit der russischen Westgrenze": *Jahrb. für A. und M.*, 1903.

(57) *Russland in Asien*, by Krahmer. Vols. 3 to 5. Leipzig, 1899 to 1902.

(58) "Russland und Indien": *Streffleur*, 1904.

(59) *Die Befestigung und Verteidigung der deutsch-russischen Grenze*, by U. v. Bonin. Berlin, 1901.

(60) "Die Schlussmanöver 1902 im Militärbezirk Warschau," *Streffleur*, 1903, and *N.M.B.*, 1903.

(*k*). SWITZERLAND.

The strategical importance of Switzerland is discussed in (61), whilst its fortifications are dealt with in (62).

(63) shows that the Swiss intend to make field fortification assist in the defence of their country. We may also mention (64), in which a historical review of the subject is given.

(*l*). SCANDINAVIA AND DENMARK.

Information concerning Denmark is to be found in (65) and (66), the latter concerning the Scandinavian Peninsula.

(*m*). ENGLAND AND THE UNITED STATES.

See Part IV.

D.—FORTIFICATION IN THE MILITARY HISTORY OF THE LAST DECADE.

The value of fortresses for the defence of a country is not universally admitted. Scheibert (67) quotes a number of writers who conclude from military history, and particularly from the catastrophe of Metz, that fortresses may easily constitute a danger to one's own army, and who see in them a two-edged sword, 'a Sphinx, destroying him who does not solve her riddle aright.'

Von der Goltz says (2) that it is very much easier to lead an army back to the shelter of the ramparts and guns of a fortress than to lead it out again from the safety it has found there.

A large number of the writers already referred to have, while investigating the value and uses of fortresses, touched upon the point here raised or discussed it thoroughly. Amongst these may be mentioned Brialmont (4), who expressly denies that it was through carrying out his principles that Marshal Bazaine tarried too long in

(61) "Armeereorganisation und militärische Leistungen der Schweiz": *M.W.*, 1893.
(62) "Allgemeine Schilderungen über die Landesverteidigung der Schweiz": *Jahrb. für A. und M.*, 1893.
(63) "Feldmässige Befestigung für die Landesverteidigung wichtiger Geländeabschnitte in der Schweiz": *Mitt. A.-und G.*, 1903.
(64) "Die Schweizerischen Landesbefestigungen": *N.M.B.*, 1903 and 1904.
(65) "Die dänische Landesverteidigung und die Befestigung von Kopenhagen": *Mitt. A.-und G.*, 1893.
(66) "Die Landesverteidigung Skandinaviens": *N.M.B.*, 1903, *i.e.* before the rupture between Sweden and Norway.
(67) *Die Befestigungskunst und die Lehre vom Kampfe.* Berlin, 4 vols., 1880, 1881, 1886, 1888.

Metz and finally met with disaster. Brialmont shows how the Marshal, had he made proper use of the Fortress of Metz, could have obtained a considerable start over the German armies in the march westwards. He might then, after joining forces with MacMahon, have led some 250,000 men to Paris, even after allowing for heavy losses before he reached the capital.

Schroeter also (9) deals with the situation at Metz in 1870, showing what this fortress actually effected and what it might have effected. He points out how, on the one hand, it might have been useful to Bazaine, if he had retired on Chalons; and how, on the other, it would have aided the adoption of a defensive position on the line of the Moselle. He then goes on to show how it might have been put to good use even under the conditions which actually existed. He shows, for instance, that the German investment by Roncourt-St. Privat could hardly have been successfully carried out, if the protection of the French left had been allotted to the fortress—a task which fell most naturally to it—and if the reserve had been brought up to the right wing. Schroeter also includes in his work descriptions of the parts played by a large number of fortresses from the time of the Seven Years' War up to 1870–71.

In (68) Frobenius deals with the tasks of almost all the French fortresses in the war of 1870–71 and with the fighting which took place for their possession, adding sound conclusions and lessons.

Rieger (10) considers that the avoidance of fortresses by many well-known generals of the past may in part be ascribed to the fact that, in those days of smaller armies, inferiority in numbers could be compensated for by skilful manœuvring, and that the fortresses were not very large. Taking as an example the use made of fortresses in the Seven Years' War, he discusses the question of the assistance which they can give the field army.

Heyde and Gundelach (16) and (18), after considering the parts played by the French fortresses in 1870–71, come to the conclusion that the use made by Bazaine of the fortifications of Metz was faulty; but they freely acknowledge that the fortress rendered valuable services to the French army, especially during the days following the 18th of August, 1870.

The mistakes made by Bazaine in his utilisation of Metz are also dealt with by Tilschkert (12), who suggests services which the fortress might have rendered up till August 16th. In reference to the Battle of Noisseville he says :—'the defeat here encountered reflected unfavourably only upon the general and his army, not upon the fortress.'

(68) *Kriegsgeschichtliche Beispiele des Festungskrieges aus dem deutsch-französischen Kriege, 1870–71.* Berlin, 1899 to 1906. Ten numbers have appeared up to the present time.

The series of articles (69) is directed against two brochures which ascribed the defeat of the French army in 1870–71 to the entrenched camps of Metz and Paris, and which wished to make out that the system of defence adopted by France after 1871 was unnecessary and dangerous.

In the course of the remarks upon the rôle which Metz filled in 1870 it is shown how the French general, had he correctly appreciated the value of the fortress as a pivot of manœuvre, should have attacked the three corps under Steinmetz on the 13th and 14th of August. He would thereby have hindered the crossing of the Moselle by the Second Army; and, if the bridges over that river above Metz had been destroyed, he would have gained the left bank before the Germans, and there have been able to fight one or more battles under favourable conditions.

Just as the opinion is widely held that fortresses may sometimes form a danger for one's own army, so do we find many who advise the attacker to have as little to do with the enemy's fortresses as possible. In this connection the article entitled (70) is of interest. To York was allotted the task of protecting the right flank of Blucher's army, which was advancing into France, and this especially involved the observation of the fortresses of Luxemburg, Diedenhofen, and Metz. These were, however, not to be captured, but merely to be crippled as to their capacity for offensive action. Weak detachments were made with this object in view. Blucher attained his object with these dispositions; but it is pointed out by the author that the fortresses of those days, generally of small size and with inferior garrisons, could only produce effect within a small area of country. Moreover, the communications of the invading Prussians were not very sensitive, as the fertile country furnished ample supplies and reinforcements could be kept concentrated. These communications towards the rear are, however, of the greatest importance in these days, as is pointed out later, and it is therefore advisable to establish strong fortresses at important junctions. In order properly to equip and garrison these places careful previous preparations and strong forces will be required. The article draws the conclusion that the whole army should be trained in fortress warfare.

It is also made clear in the concluding remarks of (21) that the higher leaders and their staffs must master the art of fortress warfare before they can hope to make the best use of their own fortifications.

Gundelach (18) expresses the opinion that the huge armies of to-day require great freedom of movement, and that the capture of

(69) "Études sur le rôle des Places Fortes dans la Défense des Etats": *Rev. de l'A. Belge*, 1894–95 and 1895–96.

(70) "Die Unternehmungen des Yorkschen Korps gegen die nordfranzösischen Festungen, 1814: Ein Beitrag zur Frage des Wertes der Festungen einst und jetzt": *M.W.*, 1903, Beiheft, p. 1.

opposing fortresses will therefore be necessary. Schroeter also (9) agrees that this will be necessary.

In (71) Frobenius considers that it will be necessary, under certain circumstances, to capture fortresses which are not situated close to the line of operation of the field army. The article (72) expresses the same view.

E.—TEMPORARY FORTIFICATION IN THE DEFENCE OF A COUNTRY.

In conclusion we will here refer to a view sometimes put forward, and mainly based upon the events of the Russo-Turkish campaign of 1877–78, which would do away with permanent fortifications and replace them by works constructed wherever the circumstances of any particular campaign rendered them necessary, making use of whatever materials were available. The establishment of depôts in which such materials would be stored would be provided for in peace time, so that suitable weapons, building materials, etc., would be obtainable when required.

As an exponent of this view Scheibert (67) says that fortresses only fulfil their object, if they succeed in forcing the enemy to make a detour, or if they impose upon him such a loss of time that his safety is thereby endangered. Even then the troops told off as garrisons are lost to the field army. Moreover, there can be no certainty that the strategical value of a fortress will hold good for all the possible cases which may arise in war.

Scheibert therefore recommends the construction of field fortifications to protect the front of the operating army and to secure important points upon its lines of communication. For this purpose full use should be made of the latest scientific and technical inventions, particularly of Schumann's armoured cupolas, which are easily transported and put in position.

A thoroughly well-organised system of railways is also required for the purpose of bringing up safely and rapidly whatever is needed in the way of materials, etc.

The book (73), which has been ascribed to Prince Krafft zu Hohenlohe-Ingelfingen, also attaches less value to permanent fortresses and lays more stress upon the importance of improvised fortifications.

(71) "Festung und Feldarmee unter Bezugnahme auf die jungsten Ereignisse auf dem ostasiatischen Kriegsschauplatz": *Deutsche Monatschrift für das gesamte Leben der Gegenwart*, October, 1904 (B.I.K.).

(72) "Die Widerstandsfähigkeit der modernen Festung und ihr Wert für die Feldarmee": *Löbell*, 1904.

(73) *Ideen über Befestigungen.* Berlin, 1888.

These views are keenly opposed by Reinhold Wagner in (74). It is here pointed out that, of all the many fortifications improvised on a large scale before 1870, only those proved successful which owed their existence to careful preparations and a large expenditure of time and labour. The proposals recently made by Buinitski (75) and Meyer (76) are mentioned and their practicability investigated, independent suggestions for the solution of the problem under discussion being afterwards given. The author points out what a quantity of material of all kinds and what a large personnel would have to be protected, even if the demands as to the strength of the works and the extent of the position were comparatively small. If even the smallest measure of success is to be hoped for from improvised fortifications, he considers that a soundly organised corps of workmen and a fortification train must be established in peace time. In conclusion he protests in the strongest manner against writers, even those who are entitled by their calling to give an expert opinion, discussing the question of improvised fortresses as if it were one of extreme simplicity.

Many of the works mentioned under the subhead 'A' express similar opinions opposing the idea of improvised fortresses.

Brialmont (4) shows that provisional fortifications, as compared with permanent works, suffer under the disadvantage that they require for their defence more and better trained troops. Moreover, a field army depending upon them for support is bound to remain close to them, for such works cannot possess sufficient power of resistance to enable them to hold their own without its assistance. This chaining up of the field army constitutes a very real drawback to improvised fortresses.

Considering the proposals in more detail, Brialmont expresses the opinion that a system of provisional fortresses must generally be arranged in two lines of works. To what extent this has been borne out by the provisional fortifications constructed during the wars of the last decade is shown by Krebs (77) and by Wagner (74).

Schroeter says (9), when speaking of Dresden, Sebastopol, Vicksburg, Richmond, and Plevna, that temporary fortification cannot take the place of permanent works; but that, under certain circumstances, it

(74) *Über provisorische Befestigung und Festungs-Improvisationen.* Berlin, 1897.

(75) "Die rechtzeitige Verstarküng strategisch-wichtiger Punkte": *Russ. Ing. J.* 1893. Extract in *Mitt. A.-und G.*, 1894.

(76) *Die Bedeutung mobiler Panzer für die schweizerische Landesbefestigung*, Aarau, 1891; *Angriff und Verteidigung moderner Panzerbefestigungen*, Aarau, 1892; and *Metz durch Panzerfronten verteidigt.* Frauenfeld, 1894.

(77) *Kriegsgeschichtliche Beispiele der Feldbefestigung und des Festungskrieges.* Berlin, 1901.

can help a great deal by adding to their size or in the formation of extensive entrenched positions. He goes very carefully into the seductive idea of establishing fortresses wherever they are wanted by means of field fortification. In conclusion he says that the maintenace, administration, etc., of the required movable fortress equipment would cost a great deal in money and labour; and that it would be extremely difficult, in these days of wars of short duration, to decide exactly when to begin sending up the material and when to start upon the works.

Rieger (10) thinks that the great advantages offered by 'extemporary fortifications' should be recognised; and particularly mentions two advantages, namely, that they cannot be reconnoitred in peace time by an opponent, and that they can be constructed just where the conditions of the war render them desirable. Whilst thus attaching great importance to them when used on a 'linear' plan, he is not in favour of their employment where a 'ring' of defences is required. He would retain permanent fortification for fortresses designed to protect localities, places of supply, junctions, etc. He further considers that a line of works intended to form a strategical barrier should be permanent in character, and that temporary fortifications should in such a case be used only to supplement the other works.

Meyer (13) points out that temporary works cannot be made shell-proof; whilst one of the principal uses of fortresses is to defend important river crossings and localities, a task which calls for fortifications of the strongest character.

PART II.

PERMANENT FORTIFICATION.

A.—PERMANENT FORTIFICATION DURING THE 10 YEARS PRECEDING THE INTRODUCTION OF HIGH-EXPLOSIVE SHELLS.

The design and disposition of fortifications has naturally been very closely connected with the progress of improvements in guns.

After the introduction of rifled guns, which ranged farther and shot more accurately than their predecessors, Girdle Fortresses gradually increased in extent.

A Girdle of Forts was established outside a town, which was as a rule surrounded by an Enceinte. All masonry was either removed altogether from exposure to direct fire (angles of descent up to 14°), or protected against this and against fire from smooth bore howitzers by means of parapets and overhead cover made of earth. These forts formed the main fighting position for the infantry and artillery; and their relief, already considerable, was in many cases increased by the construction of two lines of rampart one above the other (main parapet and lower parapet). The traverses projected from 1 to 2 mètres above the line of parapet.

As the accuracy of fire continued to increase, the artillery in forts of this kind, which were very visible from a distance, was placed at a fatal disadvantage to the artillery of the attack, which could establish its batteries on low sites. The guns of the main armament were therefore taken out of the forts and placed in the intervals in batteries of low relief (see footnote A). Infantry was placed more in advance for the protection of the artillery. In this way efficient protection was at the same time obtained for the intervals between forts, which had at first been somewhat neglected.

A. *Zwischen-Batterieen* (Counter Batteries).—Batteries situated outside the fort girdle. These may be to a certain extent prepared in peace; but they are not completed or armed until the positions of the attacker's artillery are known, for it is against these positions that such batteries are intended to act.

Anschluss-Batterie.—A battery in close contact with a fort, but outside the ditch. It is intended for heavy guns of the *Sicherheitsarmirung* (armament intended to oppose an attempt to overcome a place without regular siege operations). The cover for such a battery would be prepared in peace, and it would be completed, at the latest, when the *Kriegsausrüstung* (preparation for war) of the fortress was undertaken.

Armirungs-Batterie.—Any cover for guns, the construction of which is deferred until the 'preparation for war' is undertaken.

Meanwhile, however, high angle fire from rifled mortars had been much improved, and the loading of shells with high explosives successfully accomplished. The direct fire of guns had also increased still further in accuracy.

The experiments carried out in the early eighties with these improved guns and shells in Germany, France, and Roumania demonstrated beyond possibility of doubt the mastery that artillery had obtained over the fortifications of that day. A flood of literature on the subject followed. The majority of the writers put forward plans for reforming the art of fortification as it was then understood. A number, however, wished to make out that even permanent fortresses had no future before them; and, relying on the experiences of Sebastopol, Plevna, etc., recommended none but temporary fortifications. This latter doctrine has already been referred to in Part I., E.

Details as to the development of permanent fortifications are given by Müller (1) and others.

B.—THE MORE EXTENSIVE USE OF ARMOUR IN PERMANENT FORTIFICATION.

The plans put forward for bringing the art of fortification up to date depended almost entirely upon a book (2) which appeared just at the right time, and indicated how the existing form of cover, which was no longer capable of withstanding the new guns, could be replaced by another.

In this fundamental work Schumann first points out that the defender in fortress warfare will not be able to take advantage of the great improvements in guns—their longer range, increased accuracy, and enhanced shell power—until he ceases to offer so large a target to his opponent's fire. If, however, the defender gives up his cover and voluntarily places himself in similar positions to those which the attacker is compelled to take up—that is to say in the intervals between forts, with only slight parapets to protect him—he is not making the right use of fortification. The object of the latter is to enable the defender, by using the time and materials available in peace, to enter the contest with greater advantages than the attacker can secure. It is quite possible to obtain the advantage of presenting a small target to the enemy by employing fire from casemates instead of from open ramparts; but this necessitates the employment of armour in the construction of the works. There must not be, as

(1) *Geschichte des Festungskrieges seit allgemeiner Anführung der Feuerwaffen bis zum Jahre 1892.* Berlin, 1892.

(2) Schumann's *Die Bedeutung drehbarer Geschützpanzer, "Panzerlafetten" für eine durchgreifende Reform der permanenten Befestigung.* Magdeburg, 1884, and Potsdam, 1885.

formerly was the case, only a few heavy guns placed behind armour; but the great mass of the artillery, including that intended for the repulse of the close attack, must share in the protection afforded by it.

Schumann recommends that the large forts should be replaced by several smaller armoured batteries, or by groups of such works, having regard to the possible employment of infantry. He discusses the so-called 'Cummersdorf' experiment of 1882, and gives designs for the construction of armoured cover of the most varied kinds.

(3) is in a way a continuation of the work just mentioned. In it we are shown the part taken by Schumann in the development of the subject.

Commencing with the fixed armoured emplacement (Panzerstand) at Mainz in 1886, Schumann's powerful influence upon the question of armour is described. The author also gives accounts of the introduction of 'minimum porthole mountings,'* the building and trials of the Tegeler turret of rolled iron (Tegeler walzeisenturm), the construction of the Cummersdorfer armoured mounting (Cummersdorfer panzerlafette), and the constructions brought out since the amalgamation with Gruson (1883).

As already mentioned, almost all the plans put forward at this period for the reformation of the science of fortification suggest the use of Schumann's armoured contrivances. As an example we may mention (4). A good description is given of the methods of fortification in use at that time and their weak points, and it is recommended that a ring of forts should be constructed from $1\frac{1}{2}$ to 2 kilomètres only from the body of the fortress. This main line of defence should consist of positions about 700 mètres long, on which the bulk of the artillery would be placed, and, in the intervals between these lines, supporting works (stützwerken). These latter would be equipped with Schumann's armoured turrets (Schumannschen panzern), and would be used for searching the country in front with fire and for flanking the intervals (traditorenwirkung).† An Enceinte would be unnecessary with this arrangement.

(3) *Maximilian Schumann. Leben und Leistungen. Seine Bedeutung für die Entwickelung der Panzerfrage in der Landbefestigung*, by Schröder. Berlin, 1890.

* 'Minimalscharten-Lafette.' In this system of mounting guns in armoured turrets the gun and carriage together move (when being elevated or depressed) about a point near the muzzle. This enables a very small porthole to be used in the armour. Unless the turret itself revolves, the same principle governs the lateral movement.—(Transr.).

(4) Schott's *Zur Befestigungsfrage*. Berlin, 1886.

† 'Traditorenwirkung.' This refers to guns so placed (*e.g.* immediately behind the gorge of a work) that they are completely protected from frontal fire but can themselves fire to the flank and (in many cases) sweep the front of the next work.—(Transr.).

In (5) Rieger lays stress upon the difficulty of the engineer's task since the war of 1870–71. The engineer had at once to set about building new works, whilst the gunner had a certain amount of time and repose in which to carry out improvements in his weapons. The task of destroying works already completed or under construction at the time gave the artillery a line to work upon in improving their guns, whilst the engineer had to start work while still very uncertain as to what the artillery would succeed in accomplishing within a comparatively short space of time. The book in question goes very carefully into the proposals which were made at that time for new methods of fortification.

Two works by General von Sauer, (6) and (7), had a marked influence upon these proposals.

In the former work the author declares that, since the introduction of rifled guns and the consequent pushing outwards of the rings of forts, our fortresses at that time no longer fulfilled the main object of fortifications, which was to enable very small forces to offer the greatest possible amount of resistance. It is now far more the garrison which makes the place capable of offering resistance. He considers it opposed to the dictates of common sense to place the artillery in batteries situated in the intervals between forts and to give up the protection afforded by permanent fortification. He thinks that with long ranging field guns and the improved power of using indirect fire, an attacker would not wait for the arrival of his siege artillery before commencing a serious attack. He notes as the weakest points in the design of fortresses at that time the high forts placed at wide intervals from one another, and suggests the following remedies :—reduction of the intervals and of the size of the targets offered to the attack; avoidance of open ramparts, which are very vulnerable to vertical fire, and their replacement by really effective cover. This brings him to the employment of armoured cupolas, arranged, for instance, in two rows with intervals of from 650 to 1,300 yards.

In the second book von Sauer deals with the question of how the attack should be carried out, still bearing in mind the power of the new field guns and the improvements made in high angle fire. He advocates the introduction of a 12-c.m. (4·8") mortar as 'the advanced guard of the main body of siege artillery'; and thinks that to this advanced guard, working in conjunction with the field guns, should be allotted the task of subduing the artillery fire of the fort girdle. In order to effect this object the artillery should take the defenders

(5) *Vorschläge für Neuerungen im Gebiete der permanenten Befestigung und des Festungskrieges.* Vienna, 1886.

(6) *Taktische Untersuchungen über neue Formen der Befestigungskunst.* Berlin, 1885.

(7) *Über Angriff und Verteidigung fester Plätze.* Berlin, 1885.

by surprise and attack on different lines situated far apart. It should prevent the construction of intermediate lines of defence and reduce the forts to a state of inactivity. In the mobility of the attack, in the avoidance of any definite front of attack, which the defender would of course strengthen by all the means in his power, and 'in declining every challenge to a formal artillery duel on any intermediate line' this book sees the best promise for speedy success in the attack. As in his former work, the author recommends for the girdle small 'points of support,' protected against high angle fire and with intervals of small extent between them. It should be possible to defend these supporting points with even a small garrison, and they should be so far completed that only very little labour would be required to arm them.

General Brialmont has repeatedly written upon the question under discussion. First of all in the year 1885, in (8), he gives a very complete collection of the results obtained with artillery fire during the preceding years, and adds notes upon the artillery material of the day. After considering the modern means of attack and defence, he makes a number of proposals for meeting the demands of the future. These proposals include an extensive use of armour, but as a rule he does not depart from the generally accepted views. The existing fort girdles are retained. As before, the forts are to constitute the main fighting position for the infantry and for the artillery, although the latter will be protected by armour. These forts are to have masonry revetments, mostly arched, affording cover against fire at angles of descent up to 14°.

Brialmont soon followed up this book with another, (9), which possesses a high value, if only for the description it contains of the so-called Bucharest shooting trials compared with that of the generally accepted account. The book also deals very thoroughly with the various kinds of armoured turrets and their use, with the importance of high angle fire and with its influence on the method of arming a girdle fort or a barrier fort. From the effects produced by high-explosive shells Brialmont draws conclusions as to the best ways of constructing masonry work, especially in the case of overhead cover, for the design of the escarp and counterscarp, and he investigates the value of masonry and armour in the protection of caponiers.

In conclusion we are again given various designs for forts with wet and dry ditches. The plan of having one work to contain both infantry and artillery is retained, and most of the guns are covered by armour. Frequently the guns of large calibre are placed behind the rampart used by the infantry and lighter guns, and separated

(8) *La Fortification du Temps Présent.* Brussels, 1885.
(9) *Influence du Tir Plongeant et des Obus-Torpilles sur la Fortification.* Brussels, 1888.

from it by an inner ditch, a kind of redoubt being thus formed. Where the ditch is dry, the counterscarp almost always contains galleries or arches, the escarp being often constructed of earth alone. Caponiers for flanking fire are thrown out from the escarp, in some cases in the form of armoured cupolas.

A third work by Brialmont (10) is really directed against a number of other proposals, especially against Sauer's and Scheibert's and those in a book published anonymously in 1890 under the title *Les Forts et la Melynite*. The plans formulated by this latter book resembled the "Groups of Forts" as used at the present time. Brialmont disapproves of the use of such groups, and depends upon his large forts, designed to take both infantry and guns. He lays emphasis, however, on the value to the defenders of a mobile reserve of guns.

Frobenius (11) deals with various plans for rebuilding our fortresses. He points out that we possess these fortresses for good or ill, and that we must consequently take them into account, especially as they are mostly situated at important points. We should therefore not give them up, but add the necessary modern improvements. These forts can be of very real service, even if they are no longer used by the artillery, in affording shelter and accommodation for troops. Frobenius desires protection for the artillery, which is to be placed in the intervening ground, particularly in the shape of armoured shields. Besides carefully reviewing Meyer's (12) Frobenius touches on the two earlier works by the same author, (13) and (14).

A brief review of the question of the employment of armour by Frobenius is contained in (15).

We find a decided opponent of armour in Welitschko, who in (16) examines the various armoured constructions. He comes to the conclusion that, up to the time of writing, not a single construction had been found capable of satisfying even moderate demands, and that moreover such a one would never be found. He issues a

(10) *Situation Actuelle de la Fortification*. Ghent, 1890.
(11) "Wie können wir unsere Festungen verstärken": *Jahrb. für A. und M.*, 1894.
(12) *Metz durch Panzerfronten verteidigt*. Frauenfeld, 1894.
(13) *Die Bedeutung mobiler Panzer für die schweizerische Landesbefestigung*. Aarau, 1891.
(14) *Angriff und Verteidigung moderner Panzerbefestigungen*. Aarau, 1892.
(15) "Der heutige Stand der Panzerbefestigung": *Jahrb. für A. und M.*, 1903.
(16) *Untersuchung der neuesten Mittel für den Angriff und die Verteidigung von Binnenbefestigungen. Typus für ein modernes Befestigungssystem.* Republished in a condensed form, under the title "Russische Ansichten und Vorschläge in Bezug auf den gegenwärtigen Stand der Fortifikation," in *Mitt. A.-und G.*, 1903.

warning against the practice of affording guns armoured cover, for, he says, this leads to striving after absolutely impregnable cover, which is not to be found in any material in the world. The book treats in detail of modern siege guns and the artillery trials of the last ten years. It also gives examples of how guns and mortars should be placed in masked positions, and of permanent girdle works, while disappearing mountings are also spoken of.

A discussion by Leithner of this book is to be found in (17).

C.—The Arrangement of the Works, and the Separation of the Dispositions for Fighting at Long Range from those for Close Fighting.

Many military writers treat of these questions, particularly of the latter.

Brialmont denies the expediency of this separation (8), (9) and (10), and remains faithful to the combined artillery and infantry work (Einheitswerk). The same opinion is expressed in (18) by the Italian Colonel Rocchi and in (19) by Deguise.

Welitschko speaks in favour of this separation, not only in the book already referred to (16), but also in (20). In this latter article he opposes the methods of attack recommended by Sauer, and warns his readers against the false and demoralising idea that the means of defence cannot be brought abreast of the means of attack. He then gives a number of suggestions for the construction of fortresses, and states as his opinion that hunger would be the only means by which an enemy could reduce a place fortified according to these suggestions.

The desire to separate the arrangements for long range fighting from those for the combat at close quarters was to a great extent due to the wish not to expose to the chances of loss and injury during the earlier stages those works which were intended for close defence and which would only therefore be of use at a later period of the fight. It was also in part due to the fact that, by distributing the means of defence over a number of positions, the ground could be more effectively commanded than would be possible from one place.

(17) "Pro und contra Welitschko": *Mitt. A.-und G.* 1890.

(18) *Traccio per lo Studio della Fortificazione Permanente.* Turin, 1902. Extract in "Italienische Ansichten über die beständige Befestigung und den Festungskrieg," by Kuchinka, *Mitt. A.-und G.* 1903.

(19) *La Fortification Permanente, appliquée à l'organisation des Forteresses à Grand Développement.* Brussels, 1896.

(20) "Die Mittel zur Verteidigung der Festungen gegen den abgekurzte Angriff": from the Russian, by Kolischer, *Mitt. A.-und G.*, 1892.

Another reason was that such a system of dispersion contributed to reduce the total size of the target offered to the hostile guns.

According to Leithner (21), there were at that time three different methods of arranging the girdle forts of a fortress. He calls them the girdle system with armoured fronts (panzerfronten), that with armoured forts (panzerforts), and finally that with a complete distinction between the dispositions for close and distant fighting.

An addition to these methods of arrangement has now been made by the introduction of the "Group" system of fortification.

Leithner deals with this last method in (22). He here says that in a fortress on the girdle system, as in every defensive position of large size, the important points will be strongly held, the less important weakly or not at all; further, that the wish to keep intact as long as possible those works which are intended for close defence, and which cannot be of use until a late stage, coupled with the wish to give the enemy small targets and to make him distribute his fire, compels one to adopt the principle of separation. This necessity leads him on to the use of groups, and he proceeds to give a number of suggestions as to their arrangement.

The same writer treats of these groups in the third volume (23) of the work mentioned under (21). He points out there that it is very seldom that ground will be available which at the same time offers a good field of fire against the lines of approach and positions of assembly of the enemy, the best possible command of the foreground, and opportunities for the defender to bring up and prepare his reserves under cover. The only way of securing all these advantages is to arrange the available means of defence in groups. In (24) Rehm wishes to see the art of fortification developed principally according to the point of view of the expert in artillery tactics; for the artilleryman alone can foresee the improvements in his weapons, and these improvements are of the first importance when considering methods of fortification. He places the claims of Effect first and of Cover second. He recommends that the latter should be designed to combine the greatest possible resistance to hostile fire with the advantage of rendering observation as difficult as possible for the enemy and of affording him a small target to fire at. His proposals culminate in keeping distinct the arrangements for the long range fight, the fighting at close quarters, and the accommodation of the troops.

(21) Second edition of *Die beständige Befestigung und der Festungskrieg.* Vienna, 1894.
(22) "Die Gruppe im Festungsgurtel, ihre Gliederung und ihre Elemente": *Mitt. A.-und G.*, 1899.
(23) Vienna, 1899.
(24) *Gesichtspunkte der weiteren Entwickelung der Fortifikation.* Vienna and Leipzig, 1899.

The question of Groups is also gone into by Frobenius in (15) and by Stavenhagen in (25) and (26).

The two last-mentioned works, as also (27), give suggestions for the planning of the works and for the allied problem of flanking the ditches, as well as for the methods of constructing the latter. For the trace of a work lunettes, demi-redoubts, and redans are recommended; and the reduction of depth and the avoidance of sharp angles and edges are points to be aimed at in their construction.

Brialmont (9) compares flanking works built on to the counterscarp with those attached to the escarp, and gives proposals for tracing works and for flanking defences. In (28) the same writer says "La principale garantie contre l'attaque de vive force reside dans le flanquement et non dans l'obstacle du fosse." He also speaks of the great value of masonry escarps, and explains why they have nevertheless to be dispensed with in many cases. This book, as well as that referred to under (21), contains sketches illustrating traces of works.

Rehm (24) describes, with the aid of sketches, the Fort for both Arms (Einheitsfort), the Artillery Fort, and the 'Schroeter' Fort. The latter, as well as an Armoured Battery, is dealt with at length by Schroeter in (29).

D.—THE ENCEINTE. (*KERNUMWALLUNG*).

(*i.e.* The 'Continuous' Enceinte Placed Immediately Outside the Town Itself).

As the main power of resistance of a Fortress was transferred to the Girdle of Forts, and as the latter were steadily increasing in strength of construction, the question as to whether an Enceinte was necessary came to the front, especially as the increasing populations of most of the towns concerned made it more and more necessary that the existing enceintes should be done away with or at least increased in extent.

Schott (4), in his proposals, is altogether against any enceinte to a town. He can take this view all the more easily because his plans for fortress construction, published at other times, practically do away with the necessity for an inner line of this kind. In (30) he dismisses

(25) *Grundriss der Befestigungslehre.* Berlin, 1900.

(26) *Leitfaden für den Unterricht in der Befestigungslehre, im Verkehrswesen und im Festungskrieg auf den Königlichen Kriegsschulen.* Berlin, 1906.

(27) v. Brunner's *Die beständige Befestigung.* Vienna, 1901.

(28) *La Défense des Etats et la Fortification à la fin du XIX. Siècle.* Brussels, 1895.

(29) *Die Festung in der heutigen Kriegführung.* 2 Abteilung. Berlin, 1905.

(30) "Sind noch Festungsumwallungen nötig?": *Jahrb. für A. und M.*, 1902.

very shortly the advantages of these circumvallations, and welcomes the abandonment of several fortresses even on military grounds.

Schroeter (29) attaches little value to existing enceintes; but proposes what is to a certain extent a substitute in the form of a second line of defence, behind the main line, which would not be constructed until the arming of the fortress was undertaken.

Brialmont (28) is an out-and-out supporter of the enceinte. In favour of it he quotes a number of military writers, and refers to the question of fortification as met with in the most varied countries and under all kinds of conditions. As advantages he mentions the feeling of safety given by such a work, protection against a 'coup-de-main' penetrating between the outer forts, protection for all the various services which have to be carried out within a fortress, the connection it forms between the several forts (a connection which would force the enemy to operate against the latter from one direction only), and finally the prolongation of the fighting assured by the struggle for its possession.

Brialmont adopts very much the same point of view in (31).

In (32) Brialmont recommends these circumvallations also for the Entrenched Camps in such regions.

Somewhat the same opinion is expressed in (33), whilst (34) lays down the necessity of constructing such enceintes where this has not been done.

The article (35) speaks in favour of enceintes in connection with their having been dispensed with in several instances in Germany.

Kuk (36) thinks that the outer girdle of forts is in no case sufficient, and wants a second line of defence, although this latter would not always partake of the nature of an enceinte. The latter is unreservedly advocated by Leithner (23).

In (37) Frobenius shows how the gradual transference of the main resisting power of a Fortress to the Line of Forts resulted in the 'enceinte de siège' becoming changed into an 'enceinte de sûreté'; and how, of late years, the latter has in many cases been allowed to

(31) "Die Befestigungsweise permanent verschanzter Lager" (a translation by R. Wagner): *Jahrb. für A. und M.*, 1898.
(32) *Les Régions Fortifiées.* Brussels, 1890.
(33) *Nouveau Manuel de Fortification Permanente.* Paris, 1895.
(34) *Manuel Complet de Fortification.* Paris and Nancy, 1900.
(35) "Système de la Fortification Moderne": *Internat. Rev.*, 1904, Suppt. 61.
(36) *Die Anwendung von beständigen und Feldbefestigungen.* Vienna, 1896.
(37) "Festungs-Rayons": *Jahrb. für A. und M.*, 1901.

B. *Festungs-Rayons.* The areas of ground which come within the 'Sphere of Influence' of a Fortress in the matter of the control of building operations, etc., so that the field of fire may not be obstructed in peace time. Special laws deal with zones at different distances from the Covered Way.

fall into disuse or been abolished. He opposes the idea of leaving the construction of an enceinte until the time has come to arm the fortress, for the removal of the buildings in front of it would then be very difficult to carry out. The article in question also deals exhaustively with the subject of fortress areas (see footnote B on previous page) and their extent.

Woelki (38) considers that the enceinte has not lost its value, and that to give it up would mean a loss of defensive power. He also declares himself against the views expressed in the article referred to above (30).

E.—THE PREPARATION, ATTRIBUTES, AND COST OF ARMOUR PLATES.

SOME PATTERNS OF ARMOURED TURRETS, ETC.

When armour had taken its place among the materials used in fortification, as has been described above, knowledge of the methods of manufacturing armoured plates and of their resisting power was bound to become general. (39) supplies information on these points. Of the books which go further into the details of armour, two have already been noticed, viz. those by Schumann (2) and Brialmont (9).

Rehm (24) compares armoured casemates with armoured turrets, and comes to the conclusion that the former are to be preferred. At the same time he is generally in favour of armoured turrets for use in works intended for occupation by both artillery and infantry (Einheitswerken). With regard to the erection of armoured constructions in the latter, information is given in the works referred to under (8) and (31). Frobenius (15) describes the development of armoured fortifications during the last seven years, and goes into the questions of the composition, cost, and method of manufacture of armours. He discusses also the fighting value of guns mounted in armoured turrets.

Schroeter (29) considers the question of armour from both the tactical and technical points of view. In the latter connection he discusses the principle of 'minimum porthole mountings,'* the various forms of armoured cupolas, transportable gun-shields, and armour for search-lights and observation stations. He also deals here with the characteristics of armour generally.

R. Wagner in (40) treats of the cost of armoured constructions. He shows that the total cost of a fort is reduced by the employment

(38) "Wert der Stadtbefestigungen": *K.Z.*, 1903.

(39) *Mitt. des I.-K.*, No. 33. Berlin, 1894. Reference is also made to Nos. 11 and 22 of the same publication.

* See also under footnote (3), page 244.

(40) "Die Panzerbefestigung in ökonomischer Hinsicht beleuchtet durch das Beispiel von Lüttich und Namur": *Jahrb. für A. und M.*, 1893.

of armour, and that a fort girdle of the old kind requires a considerably larger garrison than one formed of separate armoured works.

Finally we may call attention to (41). Here are described the changes which have taken place in the application of armour during the last ten years, the improvements in the material used in the manufacture of armour, the advances made in the domain of artillery, and various improvements in methods of construction. Several armoured constructions manufactured at the works in question are described, namely gun shields for use on inland fortifications and observation shields, including those for rangefinders and for search-lights.

The article (42) deals with the extensive use of electricity as motive power for cupolas, for producing light for illuminating both the interior of works and the ground outside, for driving ventilators, etc.

F.—THE PROTECTION OF BOMBPROOF SHELTERS, ETC. (*HOHLBAUTEN*) † BY REINFORCED CONCRETE.

While armour provided a means of protection for guns, observers, and search-lights against the improved artillery of the attack, reinforced concrete offered a means of obtaining cover for shelters for the garrisons, stations for inlying picquets, ammunition and supply stores, etc.

When the trials which have already been referred to had shown of what little use the existing masonry work was against the improved guns and projectiles, the question arose as to how this form of construction was to be given the necessary resisting power. This was as a rule successfully accomplished by placing upon the existing arches a layer of sand from ·8 to 1 mètre thick, and covering this again with a reinforced concrete slab about 1 mètre in thickness.

The containing walls of shelters exposed to artillery fire were protected in a similar way. Brialmont, in the work previously referred to (9), speaks of these measures, and discusses the composition and use of various forms of reinforced concrete. He also deals with the best methods of arranging arches, counterforts (Widerlagern), revetment walls (Bekleidungsmauern), etc., and with protection against mines (Unterschiessen). In (28) he goes into the question of

(41) *Fortifikatorische Panzerkonstruktionen des Friedr. Krupp Grusonwerks.* Fried. Krupp Grusonwerk, 1903.

(42) "Les Installations Electriques dans les Forts Cuirassés": *Rev. de l'A. Belge*, 1902-03.

† The expressions "Hohlbauten" and "Hohlräume" include all the shelters, galleries, casemates, etc., which are secured from hostile shell fire. They include various types, giving protection from 'high-explosive shells,' 'field gun shells,' 'splinters,' etc. They are all translated by the term 'shelters.'—(Transr.).

protecting masonry constructions against high-explosive shell. He considers that arches should be given a thickness of from 1·5 to 3 mètres, according to their span, and that a bed of sand should intervene between such arches and the rigid armoured concrete covering above them.

The composition and uses of reinforced concrete are specially dealt with in (43) and (44).

Schroeter (29) explains the value of the modern method of construction, according to which the concrete forms a firm and rigid mass of stone, of uniform structure, round the space to be protected.

He points out the advantage of a covering of earth to localise the effects of shells and the necessity of protecting the foundations.

An instructive insight into the modern methods of employing reinforced concrete is afforded by (45).

Leithner, in the second volume of the book (21), deals with the details of masonry work in fortification.

G.—SOME SPECIAL PROPOSALS.

The necessity of having deep ditches with counterscarps of masonry leads Zell (46) to suggest, as has also been done by Welitschko, that the accommodation for the garrisons should be situated within the counterscarp wall.

Welitschko (16) will have nothing to do with armour, but is in favour of using disappearing mountings. His girdle fortress consists of a ring of fortified posts for close fighting, within which there is an intermediate glacis designed for infantry defence together with the long range guns (Kampfgeschützen), including the so-called first artillery position, and of an interior enceinte.

A somewhat different arrangement is proposed by Dupommier in (47). His outer girdle consists of a ring of works, each consisting of positions prepared for rifle fire and a redoubt armed with mortars, as well as light overhead cover. In the intervals there are more simple intermediate works and infantry positions; and behind these, forming as it were the third and fourth lines, field batteries and batteries of long-range guns (Kampfbatterien). Dupommier does not believe that it is absolutely indispensable, even with the weapons of to-day, to arrange for flanking fire along the ditches; and, holding this opinion, he gives suggestions for alterations in the existing patterns of parapets and ditches.

(43) "Über Betonierungen und deren Anwendung bei fortifikatorischen Objecten": *Mitt. A.-und G.*, 1890.
(44) "Beton in der Landesbefestigung": *N.M.B.*, 1905.
(45) "Über moderne ständige Befestigungen": *K.Z.*, 1905.
(46) "Gürtel-forts-Typen und deren Bestandteile": *Mitt. A.-und G.*, 1899.
(47) *Des Transformations de la Fortification Permanente Actuelle.* Paris and Nancy, 1904. (B.I.K.).

H.—THE PREPARATION OF THE INTERVALS AND THE ARRANGEMENTS FOR BRINGING FIRE TO BEAR UPON THEM.

A large number of the writers already mentioned deal with the ground between the works for both arms (Einheitswerke) and the works for close range fighting (Nahkampfwerke). Of these we may mention (5), (9), (16), (20), and (21), besides (25), (26), (27), (33), and (34), which are most instructive.

In close connection with the preparation of the intervals and their protection stands the problem of bringing fire to bear upon them, which has been discussed by Schroeter (29) among others. This flanking fire (Traditorenwirkung) is carried out from casemates on the flanks or gorges of the works or from armoured cupolas.

Brialmont also occupies himself with this question on various occasions, (8) and (9), and it is also discussed by Leithner (23) and Welitschko (16).

J.—PERMANENT FORTIFICATION IN FOREIGN COUNTRIES.

(*a*). GENERAL.

It may be assumed that general agreement exists at present upon the main principles of fortress construction. In matters of detail, however, the industrial and geographical conditions in different countries, and the views of persons in authority, will always result in more or less marked variations of method. As regards these details, there is of course very little published which can be looked upon as trustworthy information.

The general works mentioned in Part I., under C (*a*), contain information as to the details of fortification in various States. Besides these (48), by Brialmont, contains much that is worth knowing about the fortifications of almost every European State, and is of value to anyone studying the history of the development of permanent fortification. Finally, the article mentioned under (35) deals with modern views on fortification in France, Russia, Austria-Hungary, and Italy.

(*b*). BELGIUM.

(49), (50), (51), all by Brialmont, (52), and (53) deal with the fortifications of Belgium. (52), among other things, gives information regarding Lüttich, Namur, and Termonde.

(48) *Progrès de la Défense des Etats et de la Fortification Permanente depuis Vauban.* Brussels, 1898.
(49) *Projet d'Agrandissement d'Anvers de nouveaux Travaux de Défense et de Port Franc.* Brussels, 1900.
(50) *Agrandissement d'Anvers.* Brussels, 1902.
(51) *L'Enceinte d'Anvers.* Brussels, 1903.
(52) "Über die belgischen Festungen": *Internat. Rev.*, 1903.
(53) "Die Künftigen Festungswerke von Antwerpen": *ibid.*, 1906, Beiheft 72.

(c). FRANCE.

The fortifications of France are dealt with in (33), (34), and (47).

(d). ITALY.

Rocchi (18) discusses the Italian fortifications. He is in favour of armoured works for both arms (Einheitswerken), of large girdle fortresses, and of the preparation of the ground in the intervals. He furnishes information as to the details of a number of works which have actually been constructed in Germany, Denmark, and Roumania; and treats of fortifications in mountainous country, a subject of special importance to Italy. (54) and (55) deal also with Rome and the fortresses of Southern Italy.

(e). THE NETHERLANDS.

The following works may be mentioned:—(56), (57), (58), and (59).

(f) AUSTRIA-HUNGARY AND THE BALKAN STATES.

The sources of information are given in Part I.

(g). RUSSIA.

In addition to the works by Welitschko already mentioned, viz. (16) and (20), we may here call attention to his paper (60), in which his former objection to the use of armour is withdrawn. Other works on the subject are (61) and (62).

Particular attention has been paid in Russia to the intervals between forts. The following articles mostly concern this subject:—(63), (64), (65), and (66).

(54) "Die Befestigungen Italiens," by Kurchhoff: *Schweiz. Zeit. für A. und G.*, 1903.

(55) "Italiens Küstenschutz und Landesverteidigung": *N.M.B.*, 1903.

(56) "De Aanwending van lichte Pantsers bij de Bevestiging der Stelling van Amsterdam," by Swaving. The Hague, 1893.

(57) "Die Erweiterung der Gürtellinie von Amsterdam," by Kutzlnigg: *Mitt. A.-und G.*, 1897.

(58) "Amsterdam," by Frobenius: *Internat. Rev.*, 1897.

(59) "Das Verteidigungswesen der kleineren Staaten Nordeuropas": *N.M.B.*, 1899.

(60) "Fortifikatorische Verstärkung der Staaten und Festungsbau": *Russ. Ing. J.*, 1902 and 1903.

(61) *Abriss der beständigen Befestigung*, by Engmann. St. Petersburg, 1895.

(62) *Kurzgefasstes Lehrbuch der beständigen Befestigung*, by Jocher. St. Petersburg, 1894.

(63) "Über die Flankierung von Fortzwischenräumen": *Russ. Ing. J.*, 1895.

(64) "Einige Vorschläge aus dem Gebiete der ständigen Befestigung": *ibid.*, 1900.

(65) "Fortifikatorische Zwischenbauten": *ibid.*, 1903.

(66) "Entwürfe gebrochener Zwischenräumstreichen an den Kehlpunkten ständiger Forts": *ibid.*, 1903.

A very comprehensive view of the subject is given in (67).

A work by Buinitzki (68) has been introduced as a text book at the Russian Nicolajew-Ingenieurakademie.

The following deal with certain Russian Fortresses :—(69), (70), (71), (72), (73), and (74).

The literature of the Russo-Japanese War, which contains among other things much information regarding the fortifications of Port Arthur, is given in Appendix 1.

(*h*). SWITZERLAND.

(75) provides information as to the development and present condition of the fortifications of Switzerland. (76) deals, among other things, with the fortifications of the St. Gothard, whilst (77) treats of the works on the line of the Zihl.

(*i*). SCANDINAVIA AND DENMARK.

The following articles furnish information :—(78), (79), and (80).

(*k*). ENGLAND AND THE UNITED STATES.

(See Part IV.).

K.—BARRIER FORTS (*SPERRFORTS*).

In (81) it is explained that the object of Barrier Forts never is to place an impregnable wall of defences in the way of the enemy, but

(67) "Russische Anschauungen über Festungskrieg und ständige Befestigung nach der neuesten russischen Literatur": *Mitt. des I.-K.*, No. 35. Berlin, 1904.
(68) *Gegenwärtiger Stand der ständigen und behelfsmässigen Befestigung.* St. Petersburg, 1903.
(69) "Port Arthur, Dalni und Wladiwostok": *Mar. Rund.*, 1903.
(70) "Port Arthur": *Mitt. A.-und G.*, 1903.
(71) "Die Befestigungen von Port Arthur": *K.Z.*, 1904.
(72) "Die Kriegshafen Port Arthur und Wladiwostok und der befestigte Hafen von Dalni": *Mitt. A.-und G.*, 1904.
(73) "The Kaiser Alexander III. Harbour at Libau": *Jour. R.U.S.I.*, 1899.
(74) "Der Kriegshafen von Kronstadt": *Schweiz. Zeit. für A. und G.*, 1904.
(75) "Die Schweizerischen Landesbefestigungen": *N.M.B.*, 1903 and 1904.
(76) "Die Befestigungen der Schweiz": *K.Z.*, 1902.
(77) "Die Befestigungen am Jolimont": *Mitt. A.-und G.*, 1903.
(78) "Über Erweiterung der Festung Boden am Schnittpunkte der schwedischen Nordbahn und der Linie Lulea-Narwik": *M.W.*, 1904.
(79) "Mitteilungen über die neuen Befestigungen von Kopenhagen": *Archiv. für A.-und Ing. Offiziere*, 1893.
(80) "Die neuen Befestigungen Kopenhagens": *Jahrb. für A. und M.*, 1894.
(81) *Die Festung in den Kriegen Napoleons und der Neuzeit. Studien zur Kriegsgesch. und Taktik*, herausgegeben vom Gr. Gen. Stabs. Kriegsgeschichtl. Abtlg. I. Bd. 4. Berlin, 1905.

to delay him and compel him to use certain roads and railways. This book regards the use of armour in fortification as a means of increasing the value of these forts.

The book (33) takes a similar view of the purpose of these forts, whilst going further into the question of their disposition. Brialmont, (8), (9), (28), and (48), goes very thoroughly into the matter of Barrier Forts, giving ample instructions in the text, with the aid of illustrations, as to their construction and matters of detail.

It has already been mentioned that Rocchi (18) deals with the question of barrier fortifications, which are of special importance to Italy. Kuk (36) also approves of these forts, especially for use in mountainous country. Leithner (21) is of the same opinion and discusses the methods of employing barrier works in open country and among mountains. He also gives examples of Mountain Blockhouses and Mountain Forts.

PART III.

IMPROVISED FORTIFICATION, FIELD FORTIFICATION, AND OTHER TECHNICAL ENGINEER WORK.

A.—GENERAL.

The domain of what is generally understood by the expression "Permanent Fortification" is bounded by clearly defined limits, but this is not the case with the other methods of fortification. Such expressions as Provisional or Improvised Fortification, and Position, Battlefield, or Field Fortifications, are so indefinite in themselves that most military writers begin by explaining the sense in which they propose to use the terms in question.

B.—IMPROVISED FORTIFICATIONS.

DEFINITION AND OBJECTS.

Wagner (1) defines provisional or improvised fortification as an expedient used in place of permanent fortification. The principal task of the latter is, according to this writer, to ensure possession of strategically important localities with the smallest possible force. He thinks that improvised fortifications will often suffice for the carrying out of work which is not of much intrinsic importance. As examples may be mentioned:—detached works,—independent or forming extensions of permanent works—and circumvallations upon the resisting power of which too great demands will not be made.

Kuk (2) characterises provisional fortifications, from the military point of view, as errors deliberately committed, because their construction in permanent form in peace time is omitted on non-military grounds.

Stavenhagen (3) assigns to provisional fortification a 'hybrid' status between permanent and field fortification. He would employ it as an expedient in place of permanent works, for extending and completing the latter, and for the preparation of positions in the field.

Leithner, in (4), gives it the same rôle; and also says that such work would be undertaken only when war was imminent, or during the course of a campaign.

(1) *Über provisorische Befestigung und Festungs-Improvisationen.* Berlin, 1897.
(2) *Die Anwendung von beständigen und Feldbefestigungen.* Vienna, 1896.
(3) *Grundriss der Befestigungslehre.* Berlin, 1900.
(4) "Die provisorische Befestigung": *Mitt. A.-und G.*, 1895.

Schroeter (5) investigates the question of whether improvised works can actually take the place of permanent fortifications, and arrives at a negative conclusion.

The French (6) find that the most suitable use for improvised fortifications is the strengthening of localities of which an army may, in the course of the operations, require to make use. Scheibert also, who is generally in favour of the widest use of improvised fortifications, says (7) that it may well happen in the course of a war that a stubborn resistance may be necessary for the defence of the country at places where no fortresses exist. He would in such a case recommend the improvisation of a fortress.

In (8) v. Brunner says that provisional fortifications will either be commenced on the outbreak of a war, or they will be prepared in peace time to the extent of having the earth work completed, plots of ground prepared for the erection of wire entanglements, and accommodation for the garrisons constructed. They should be of a nature to compel the attacker to bring up numerous and heavy guns.

C.—MATERIALS AND GENERAL ARRANGEMENTS.

According to Leithner (4) improvised fortifications are limited as to time of construction and as to technical materials, a disadvantage which is not compensated for even by the comparative freedom from considerations of expense of which they permit.

Leithner gives some views as to the general arrangement of a girdle, and favours a complete separation of the dispositions for the fight at long range from those for the close combat. He thinks that light armour should be made use of in cases where it can be prepared in peace time. He is of opinion that, in the case of provisional fortifications even more than in that of permanent works, the necessary power of resistance depends, above all things, upon fire effect. He therefore recommends, as the best preparation for the provisional fortification of a place, that a modern park of guns should be established and ample field railway material kept in readiness.

In attempting to reconcile the idea of improvised fortresses with the possibility of their being actually made use of, Wagner (1) carries his study of the construction of such works into matters of detail. The results of his investigations are to be found above in Part I., E.

In (9) Rehm assigns the simplest materials to provisional fortifica-

(5) *Die Festung in der heutigen Kriegführung.* Berlin. 1 Abtlg., 1903; 2 Abtlg., 1905.

(6) *Manuel Complet de Fortification.* Paris and Nancy, 1900.

(7) *Die Befestigungskunst und die Lehre vom Kampfe.* Berlin. 4 vols., 1880–81–86–88.

(8) *Die beständige Befestigung.* Vienna, 1901.

(9) *Gesichtspunkte der weiteren Entwickelung der Fortifikation.* Vienna and Leipzig, 1899.

tions, saying that works of this class need only be proof against high angle fire with 15-c.m. (6″) projectiles. It is nevertheless doubtful whether a complete girdle of improvised works can be constructed in time to be of use in war. The author thinks that the principal object of fortifications of this kind is to stop the enemy's advance. With this object in view he would place long-ranging batteries, well protected from the possibility of capture by storm, on commanding points, and works for close fighting, high angle fire batteries, and mobile batteries in the intervals. It is of special importance that the works, whilst possessing as great a power of resistance as possible, should cause observation to be as difficult as possible for the enemy and offer him a small target to fire at.

Schroeter (5) considers that masonry and iron should only be employed to a limited extent in provisional fortification. He does not think that the disadvantage of having but a short time in which to construct such works can be neutralized by making use of a great quantity of labour, for it is impossible to employ more than a certain number of men profitably on a given piece of work. His further treatment of the subject is referred to under E in Part I.

The French (6) contemplate the construction of a girdle of forts by the use of provisional fortification.

Stavenhagen (3) says that in work of this nature profitable use can be made, not only of earth, wood, and wattle work, but of more powerful materials, including reinforced concrete, whilst only seeking protection against high angle fire from guns of 12 to 18-c.m. (4·8″ to 7·2″) calibre. Safety from the high-explosive shells of heavy mortars is not to be expected as a rule with fortification of this nature, but it may be possible to obtain it occasionally for special purposes (*e.g.* the protection of magazines). In the case of provisional fortification the choice of positions offering natural advantages is of special importance. Only small provision can of course be made for shell-proof and overhead cover.

v. Brunner (8) recommends that provisional works should have dimensions as small as is consistent with efficiency. They should give protection against projectiles of medium calibres—7·2″ howitzers—and should be provided with obstacles within short range or ditches about 4 mètres (about 13 ft.) deep. Arrangements for flanking the latter can often be provided for in the original trace of the work, *e.g.* by the use of "bastioned" faces. The garrison and artillery armament should be of good quality and large, in order that diminished resisting power may be counteracted by an active system of defence.

In (10) the erection of provisional fortifications is discussed, and it is recommended that splinter-proofs should only be provided for a few

(10) "Notes concernant les Redoutes à construire dans la Guerre de Siège": *Recueil des Travaux Techniques des Officiers du Génie de l'Armée.* Belge, 1900. Extract in *Mitt. A.-und G.*, 1901.

guards or picquets. The garrison itself should obtain cover by making use of the features of the ground in rear. The author grounds his opinion upon the impracticability of putting up armoured constructions, even of the dismountable kind, quickly enough, and upon the fact that reinforced concrete takes too long to set. In (11) the value of localities fortified in this way under the most varying circumstances is dwelt upon, as well as the value of such provisional works for the attack and for the defence. The detailed dispositions are discussed at length.

D.—DETAILS.

The strength of the cover provided depends, naturally, upon the nature of fire to be resisted. (12), (13), (14), (15), (16) are books that are useful when making a thorough study of the weapons concerned.

A general review of the different weapons, and of their effects, is given among others in the books (3), (4), (5), and (8).

Leithner (4) gives a design for a close range supporting work for infantry and light guns. The latter are intended to be brought from under cover, specially provided for them, into the firing line, when necessary. Free use is made of reinforced concrete and masonry. Batteries for fighting at long range, and a work intended for artillery and infantry, are also described.

Wagner (1), after discussing the practicability of constructing improvised fortresses on the lines of the proposals put forward by Buinitzki and Meyer, gives his suggestions as to how the idea of such improvised fortresses can best be realised. In these proposals for the general arrangement of a girdle of fortifications consisting of main works and intermediate works, it is intended to make comprehensive and varied use of all the materials available for provisional fortification, including reinforced concrete and armoured cupolas.

For information regarding the latter we may refer the reader to (17), (18), and (19).

Schroeter (5) applies provisional fortification to the construction of a girdle in a particular piece of country, and gives the design for a work for close range fighting intended exclusively for infantry. He refers to the establishment of lines of railway.

(11) "Études sur les Places du Moment": *Rev. du G.M.*, 1895.
(12) *Waffenlehre*, by Wille. Berlin, 1905.
(13) *Handbuch der Waffenlehre*, by Korzen and Kuhn. Berlin, 1904.
(14) *Waffenlehre*. Vienna. Sections 8*a*, 11, 12, and 13 appeared in 1906.
(15) *Wiederholungsbuch der Waffenlehre*. Berlin, 1906.
(16) *Leitfaden für den Unterricht in der Waffenlehre auf den königlichen Kriegsschulen*. Berlin, 1904.
(17) *Friedrich Krupp Grusonwerk; Geschützpanzer für provisorische Befestigungen*. 1896. (B.I.K.).
(18) *Fortifikatorische Panzerconstruktionen des Friedr. Krupp Grusonwerks*. 1903.
(19) Tilschkert's *Neue Formen der Panzerfortifikationen*. Vienna, 1902.

Zell (20) presents the general views as to the construction of a girdle of forts by this method of fortification, and gives two designs for works intended for close range fighting. In these the reinforced concrete roofing for the covered portions is constructed according to the so-called "Engmann method," *i.e.* rails or girders are placed on the ground, and upon these the layers of concrete are placed to the required thickness. The underground rooms, or galleries, are then formed by digging away the earth from under the rails or girders. This method is said to accelerate the work of construction. Von Brunner (8) also recommends detached works for provisional fortification.

The calculations as to the resisting power requisite for provisional works given by Buinitzki in (21) are most interesting. The various means of attack by artillery are given and also a formula for calculating the amount of penetration of different projectiles; and the thickness of the covering material, both vertical and horizontal, is calculated. This article recognises the distinction often made between provisional and semi-permanent works, in that the former have ordinary 'overhead cover' (Unterstanden) and mine galleries, and the latter contain shelters of a simple kind but constructed with the aid of masonry.

The above-mentioned article by Buinitzki occasioned, in Russia, a number of proposals for provisional fortifications (22). These were very thoroughly worked out, and included dispositions for the garrisons, armament, traces, flanking of ditches, and the methods of construction to be used for overhead cover and parapets. All kinds of different materials, with the exception of armour, were to be employed.

Further information on the subject of provisional fortification is to be found in (23) and (24).

E.—FIELD FORTIFICATION.

VALUE, OBJECTS, AND MEANS OF CONSTRUCTION.

The general considerations governing the employment of field fortification and other technical engineering work are discussed in (25) and (26).

(20) "Zum gegenwärtigen Stande der provisorischen Befestigung": *Mitt. A.-und G.*, 1904.
(21) "Zum Entwurf provisorische Land und Küstenbefestigungen": *Russ. Ing. J.*, 1901; *Mitt. A.-und G.*, 1902.
(22) *Mitt. A.-und G.*, 1904.
(23) *Stratégie et Grande Tactique d'après l'Expérience des Dernières Guerres*, by Pierron. Paris, 1896.
(24) *La Fortification Passagère et la Fortification Mixte ou Semi-Permanente*, by Deguise. Brussels, 1904.
(25) "Kreigstechnik und Truppenführung": *K.Z.*, 1904.
(26) "Über die technische Verwendung der Feldpioniere": *M.W.*, 1904.

Field fortification will here be dealt with within the limits ascribed to it in the pocket-book (27).

Since field fortifications have almost always to be constructed by the troops themselves, Frobenius (28) thinks that the instructions for field fortification should be placed in close conjunction with the regulations for field exercises (Exerzierreglement). He points out that, of all the different natures of fortification, field fortification alone excites any real interest in the German army, for its value was shown during the war of 1870–71, and it is to be seen on every practice ground. A comparison is made between the instructions for field fortification, which had recently appeared, and those in (29).

In (30) the saying of Napoleon, that entrenchments, properly employed, are always useful, never harmful, is referred to. Entrenchments enable extensive positions to be held by comparatively few troops, and are also of value in the attack as points from which further advance can be made.

Stavenhagen (3) considers that the value of field fortification has increased greatly owing to the rapid course of modern wars, the large size of the armies employed, and the great effects obtainable by fire against an enemy in the open.

In (31) v. Brunner expresses his opinion that the main object of field works is to improve one's own fire effect and to reduce that of the enemy. Deguise (24) deals with the materials available for field fortification and the effect upon them of the weapons in use.

Von der Goltz (32) sees in artificial strengthening of the ground, next to the skilful choice of a position, the best means of securing safety from hostile fire. In (33) he refers to the moral effect of entrenchments, especially upon the troops which have to attack them.

The article (34) emphasises the importance of field fortification; and Frobenius in (35) says, with reference to certain undertakings during the Spanish-American War, that in many instances it was only the use of field fortification that enabled the Spaniards to hold out against the superior forces of the Americans opposed to them.

(27) *Für den Pionieroffizier*, Section III. Berlin, 1904.
(28) "Der heutige Standpunkt der Feldbefestigung und die Feldbefestigungsvorschrift": *Jahrb. für A. und M.*, 1893.
(29) *Instruction sur les Travaux de Campagne à l'Usage des Troupes d'Infanterie, approuvée par le ministre de la guerre le 15 novembre, 1892.* Paris, 1893 and 1902.
(30) "Stratégie de Combat, XXVII.; La Fortification de Campagne": *J. des S.M.*, 1895.
(31) *Leitfaden für den Unterricht in der Feldbefestigung.* Vienna, 1898.
(32) *Krieg und Heerführung.* Berlin, 1901.
(33) *Das Volk in Waffen.* Berlin, 1899.
(34) "Die Schlachtfeldbefestigung in der modernen Kriegführung": *N.M.B.*, 1905.
(35) "Befestigte Stellungen im Lichte kriegerischer Ereignisse in den Jahren 1898 und 1899": *ibid.*, 1900.

Various writers have suggested classifying field fortification according to methods of employment, time of construction, etc. Of these we may mention (36), which distinguishes between "fortification du champ de bataille" and "fortification de position"; and the *Manuel Complet* (6), which founds a distinction between "fortification du champ de bataille" and "fortification passagère" upon some simple historical examples. Kuk also (2) distinguishes between "fleeting fortification" (flüchtiger Befestigung) and field fortification, the former being carried out by the troops alone, and the latter with the help of civilian workmen and mechanics.

F.—GENERAL ARRANGEMENTS.

A general survey of the question of establishing large fortified positions with the aid of field or provisional fortification is contained in (37). Kuk also (2) deals with the subject of field fortifications.

In (38) Weiss discusses the occupation of a defensive position; the reconnaissance of the different sections by officers of all arms whilst the cavalry remains in touch with the enemy; the pushing out of outposts, without allowing them to take up too extended a line; and the dispositions to be made for the main line of defence.

(39) says much that is worthy of attention as to the arrangement of cover in the field, and gives descriptions of the engagements. Von der Goltz, (32), when talking of the great advances which have been made in the weapons of the attack, recommends, for a defensive position, long lines of low relief which conform to the shape of the ground. These trenches should, even in colour, be made to resemble their surroundings as closely as possible.

The pocket book (27) deals with field fortification; and, to avoid repetition, we may say that it also treats of the subjects which will be mentioned under subheads H to N of this Part.

In (40) Maggiorotti deals with field fortification in its relation to tactics. This Italian officer adopts the principle of dividing a position into several lines, one behind the other, describing these as the 'advanced position,' the 'main position,' and the 'redoubt position.'

(36) Dupommier's *De la Fortification de Campagne*, Paris and Nancy, 1905, and *Rev. du G.M.*, 1904.

(37) *Kampf um vorbereitete Stellungen*, by Bernatsky. Berlin, 1904.

(38) "Über moderne Schlachtfeld-befestigung": *M.W.*, 1899, Beiheft, p. 209.

(39) "Die militärischen Betrachtungen über den Krieg in Sudafrika": *M.W.*, 1901, Beiheft, p. 367.

(40) *La Fortificazione Passagera coordinata alla Tattica ed il compito dell' Ufficiale del Genio nelle svariate sue Applicazioni.* Rome, 1900. Reviewed in *Mitt. A.-und G.*, 1901.

Obstacles are placed from 400 to 500 mètres in advance of the works. The author considers that all the men in the ranks should carry entrenching tools. It is interesting to note that the author does not regard the heavy artillery of the field army as a dangerous opponent of field fortifications.

Ideas as to the organization of extensive positions are to be found expressed, in connection with the war in question, in (41). A synopsis of the subject is given in (42).

Both in a field campaign and in fortress warfare, field fortification can be of use both to the attacker and to the defender. For more upon this point see subheads G and N of this Part.

G.—DETAILS.

For a more complete study of the effects of the weapons likely to be employed against field fortifications the reader should consult the works mentioned under subhead D.

The entrenching tools available for the use of the troops in constructing fieldworks are described in (3), (6), (31), and (42) and other books.

The details of earthworks are referred to in (3), (6), (31), (27), and (42), as well as in (43) and (44). The plan of arranging the works of defence in groups is dealt with in particular in (3) and (44). Book (42) treats of loopholes and head cover, and in (36) a shield is recommended for the protection of riflemen.

All the writers referred to are alike of opinion that only masonry of great strength will give protection against shells. At the same time they do not think that villages in the fighting line are always to be avoided. They cannot well be left to be occupied by the enemy, and will therefore often have to be included in the defensive position.

The advantages of villages—*e.g.* for the protection of reserves, both when halted and on the move, from view, etc.—are for the most part fully recognised (8) and (44). Their use in defence is referred to in (3), (6), (27), (43), and (44). These five books also deal thoroughly with the methods of making use of woods, walls, hedges and the like, and the disposition of obstacles, etc.

(41) "Der Feldzug in Virginien, 1864-65; Ein Beispiel modernen Positionskrieges": *Internat. Rev.*, 1903, Beiheft 36.

(42) Philips's *Textbook of Field Engineering*. London, 1901.

(43) *Taschenbuch für den Pionierunteroffizier*. Berlin, 1904.

(44) *Leitfaden für den Unterricht in der Befestigungslehre, im Verkehrswesen und im Festungskrieg auf den Königlichen Kriegsschulen*. Berlin, 1906.

Here may also be mentioned (45), (46), (47), (48), (49), (50), and (51).

H.—THE PASSAGE OF RIVERS.

Books (3), (6), (27), (43), and (44) deal with this subject as well as with the branches of engineering mentioned under subheads J to N later on.

(52) describes the organisation of the bridging trains and the equipment of the field army as regards technical engineering work in the following countries:—Germany, Austria, Russia, France, and Italy.

Bridging equipments are dealt with by Ripper in (53) and by Meyer in (54). In the latter work the conclusion is come to that our bridging equipment is no longer equal to its task. A good review of the subject by Stavenhagen is to be found in (55).

Of works by Pukl may be mentioned (56) and (57). The latter describes the action of the engineers in connection with the occurrence in question, and deals with the restoration of bridges which have been destroyed, etc. The same class of work is dealt with in (58).

The articles (59) and (60) are founded upon official sources of information and officially conducted experiments. In the latter of these two articles it is recommended that the artillery should receive training with the engineers in the execution of work of this character.

(45) "Über Schützengraben im spanisch-americanischen Kriege": *N.M.B.*, 1900.
(46) "Beobachtungsstände in Infanteriedeckungen": *Mitt. A.-und G.*, 1903.
(47) "Spatenarbeiten der Infanterie": *Streffleur*, 1905.
(48) "Praktische Erfahrungen über Spatenarbeiten im Angriff": ditto, 1906.
(49) "Geländeverstärkung während des Gefechts": *Jahrb. für A. und M.*, 1906.
(50) "Der Kampf um Stützpunkte": *Schweiz. mil. Zeit.*, 1906.
(51) *Taktische Spatenarbeit*, by Schmidt. Berlin, 1899.
(52) *Mitt. des I.-K.*, No. 39. Berlin, 1905.
(53) "Die europäische Kriegsbrückensysteme": *Mitt. A.-und G.*, 1895.
(54) "Brückentrains und Brückenschläge in Verbande eines Armeekorps nach Einführung der schweren Artillerie des Feldheeres": *Jahrb. für A. und M.*, 1901.
(55) "Das Überwinden von Wasserlaufen in kriegstechnischer Hinsicht": *Prometheus* (Illustrirte Wochenshrift über die Fortschritte in Gewerbe, Industrie, und Wissenschaft), Berlin, 1906.
(56) *Über Flussübergange und über Flussübergangs-Übungen.* Vienna, 1898.
(57) *Allgemeine und militär-technische Betrachtungen über die Hochwasserkatastrophe Ende Juli, 1897.* Prague, 1901.
(58) "Die Tätigkeit der k. und k. Pioniertruppe bei Hochwasserkatastrophen in Jahre, 1903": *Mitt. A.-und G.*, 1905.
(59) "Überschiffen von Geschützen und Führwerken mit Notmitteln": *ibid.*, 1903.
(60) "Notüberschiffungsmittel für Artillerie": *ibid.*, 1904.

(61) describes various expedients for crossing wet ditches. The same subject is dealt with in (62). We may also call attention to (63) and (64).

The following articles deal with the crossing of rivers by cavalry divisions :—(65), (66), and (67).

Crossings effected with the aid of ice are discussed in (68).

J.—THE USE OF EXPLOSIVES AND MINE WARFARE.

The use of electricity for exploding mines is thoroughly dealt with by Stavenhagen in (69).

In (70) Frobenius considers it probable that, in fortress warfare, it will only be possible to destroy certain works of the defence by pushing forward underground. Among such works he mentions the steel fence on the counterscarp and the caponiers attached to the counterscarp. He is therefore in favour of the establishment of a corps of miners. In (71) Stavenhagen comes to the same conclusion, and thinks that the vast technical resources of the present day should be used in the perfection of the art of mining as applied to war. He quotes, among other devices, the method of expediting the driving of mine galleries invented by Gillet, a Belgian engineer officer. This method, as used to-day, is described in (72).

(73) and its "Addenda" (74) are very instructive on the subject of Gillet's method.

Following on Stavenhagen's article (71), (75), by Kutznligg, goes closely into the views of various military writers upon the subject

(61) "Note concernant quelques Passarelles Flottantes": *Recueil des Travaux Techniques des Officiers du Génie de l'Armée Belge*, 1902.
(62) "Flussübersetzung mit Ballenflossen": *Mitt. A.-und G.*, 1905.
(63) "Zur Technik der Flussübergänge Napoleons I.": *M.W.*, 1902.
(64) "Folgerungen aus dem Donauübergange der Russen bei Sistowa am 27 Juni, 1877": *K.Z.*, 1904.
(65) "Kavalleriebrückentrains": *Mitt. A.-und G.*, 1903.
(66) "Die Technik im Dienste der operativen Tätigkeit einer Kavalleriedivision": *Jahrb. für A. und M.*, 1904.
(67) "Technische Hilfsmittel der (deutschen) Kavalleriedivisionen": *Mitt. A.-und G.*, 1905.
(68) "Überschreiten unvollständig zugefrorener Wasserläufe": *ibid.*, 1902.
(69) "Über elektrische Minenzündung": *Mitt. A.-und G.*, 1905.
(70) "Festungsangriff": *Jahrb. für A. und M.*, 1898.
(71) "Überblick der geschichtlichen Entwickelung des Minenkrieges": *Mitt. A.-und G.*, 1899.
(72) "L'Art Militaire à l'Exposition Universelle de Liège en 1905: Régiment du Génie": *Rev. de l'A. Belge*, 1905.
(73) "Construction Rapide des Mines": *Recueil des Travaux Techniques des Officiers du Génie de l'Armée Belge*, 1897, 1902.
(74) *Ibid.*, 1900.
(75) "Über den Minenkrieg und dessen Zukunft": *Mitt. A.-und G.*, 1899.

of future mine warfare and into certain methods of procedure in constructing mine galleries.

In (76) Scharr deals with this nature of warfare, with special reference to the views expressed by Brialmont in (77).

The question of the most suitable sectional dimensions for mine galleries is discussed in articles (78) and (79). The latter is taken from the Russian *Invalides*, and is founded on the experiences of Port Arthur. (80), by op ten Noort, may also be mentioned.

Finally attention is called to (81), which deals, among other things, with the importance of mines in fortress warfare; and to (82), by Stavenhagen, who demonstrates the necessity for using mines in the warfare of to-day.

Sea mines are considered in Part IV.

K.—ENCAMPMENTS.

Besides the works referred to under "H," we may here mention (83).

L.—COMMUNICATION, OBSERVATION, AND RECONNAISSANCE.

See also Parts IV. and V.

(84), by Schmiedecke, whilst avoiding many details, deals comprehensively with these subjects and contains sketches and examples taken from history. Information is given as to the organisation of railways in peace and war, their use for the initial deployment and for lines of communication, their construction, and their interruption. The question of using electricity in this connection is discussed. Field railways and light railways are dealt with thoroughly. In the section dealing with telegraphs, it is pointed out that the army is not yet sufficiently familiar with their practical use to be able to frame messages concisely enough. The latest introductions in the way of signalling apparatus and wireless telephony will only serve to supplement, not to replace, the existing system of communication by telegraph.

(76) "Über Minenkrieg": *K.Z.*, 1902.
(77) "Organisation et Composition des Troupes du Génie et de l'État-Major de cette Arme": *Rev. de l'A. Belge*, 1900–01.
(78) "Minengänge für Unterkünfte und Depotzwecke," by Nerad: *Mitt. A.-und G.*, 1900.
(79) "Fougassen (Flatterminen) im Feld und Festungskriege": *Streffleur*, 1905.
(80) "Ein neues Minensystem": *K.Z.*, 1906.
(81) "Saragosse, Sebastopol, Paris, and Port Arthur": *Internat. Rev.*, 1905, Suppl. 72, taken from *Die tägliche Rundschau*.
(82) "Über den unterirdischen Krieg": *Schweiz. Zeit. für A. und G.*, 1905.
(83) "Winterunterkünfte in der Mandschurei": *Streffleur*, 1905.
(84) *Die Verkehrsmittel im Kriege.* Berlin, 1906.

The use of wireless telegraphy in fortresses, in the navy, in coast defence, and in the field is discussed. The thorough instruction of the men in the means of communication is especially necessary. In dealing with the question of balloons, Germany is stated to be ahead of other powers, owing to the introduction of the sausage-shaped "Drachen" or kite balloon.

Mechanically propelled vehicles can be made use of in very many forms, from the motor bicycle to the traction engine, for work in the field and upon the lines of communication. Water communications, carrier pigeons, and war dogs are mentioned.

In (85) Stavenhagen begins by saying that war is essentially a matter of communications on a very large scale, and that it therefore obeys the laws of communications in its dealing with large distances and its striving to overcome all obstacles in its path. As means of communication he mentions railways, including field railways, natural and artificial waterways, the sea, highways and roads of all kinds. Each one of these is thoroughly discussed; and, in the case of railways particularly, notes are given as to the preparations which should be made in peace for transport in war.

Seventeen different methods of conducting observation and transmitting messages are given in the book. We may here mention from among them aerial navigation, pigeon post, war dogs, electrical, optical and submarine telegraphy, telephones, wireless telegraphy, automobiles, and searchlights. In connection with the latter the vehicles used for the transport of searchlight material in field and mountain warfare are described.

The work in question deals with the organisation of the troops assigned to the various duties of communication, observation, and the conveyance of information in the armies of the different States; and also gives a number of historical examples.

(86) and (87) also bear on this subject.

Among works dealing with telegraphy and telephony are (88), (89), (90).

Various means of illumination are dealt with by Scharr in (91).

(85) *Verkehrs, Beobachtungs und Nachrichtenmittel*. Göttingen und Leipzig, 1905.
(86) "Die Nachrichtenmittel im Feldkriege unter besonderer Berücksichtigung der deutschen Armee," by Kurchhoff: *Schweiz. Zeit. für A. und G.*, 1905.
(87) *Die Luftschiffahrt, ihre Vergangenheit und ihre Zukunft, insbesondere das Luftschiff im Verkehr und im Kriege*, by Moedebeck. Strassburg, 1906.
(88) "Der Anwendung der telegraphie ohne Draht zur Nachrichtenübermittelung für die Zwecke des Landheeres": *M. W.*, 1904.
(89) "Die Funkentelegraphie": *Streffleur*, 1906.
(90) "Der Fernsprecher im Schiessdienst": *K.Z.*, 1906.
(91) *Der Festungkrieg und die Pioniertruppe*. Berlin, 1905.

Besides searchlights and rockets, pistols for firing stars (Leuchtpistolen) and torches are mentioned. The technical aspect of searchlights and the method of mounting them are discussed in (92).

Grigar deals with the question of pigeon post in (93).

M.—THE LANDING OF OVERSEA EXPEDITIONS.

The disembarkation of such expeditions is dealt with at length in Part IV. We shall only mention here books (27) and (43).

N.—FORTRESS WARFARE.

According to von der Goltz in (94), the siege of Port Arthur marks an unusually vigorous advance in the work of the engineer. This nature of work is dealt with in (5), (27), (43), and (91), and in the books mentioned under headings E to H and K to T of Part V.

O.—PROVISIONAL AND FIELD FORTIFICATION AND TECHNICAL ENGINEER DUTIES IN FOREIGN COUNTRIES.

(*a*). GENERAL.

See Part I., C (*a*).

(*b*). FRANCE.

The following works should be noticed:—(95), (96), and (97). In these the different modern views upon field fortifications are discussed. Piarron de Mondesir, in (98), gives a "possible solution" of the question of the use of entrenchments against quick-firing guns and modern projectiles.

(*c*). ENGLAND.

Special interest has been shown of late years by English writers in the subjects which we are considering. We may mention (99),

(92) "Scheinwerfer": *N.M.B.*, 1905.
(93) "Das Militärbrieftaubenwesen in verschiedenen europäischen Staaten": *Mitt. A.-und G.*, 1905, 06, and 07.
(94) "Port Arthur; ein Rückblick": *Deutsche Revue*, 1905.
(95) *Aide-Mémoire de l'Officier d'État-Major en Campagne.* Paris and Limoges, 1902.
(96) "Les Travaux de Fortification de Campagne et l'Armament Actuel": *Rev. du G.M.*, 1904, and *Rev. de l'A. Belge*, 1905.
(97) "Défense Offensive dans l'Attaque Décisive et Reconnaissance d'État-Major de la Position de Magny-Fouchard": *Rev. du G.M.*, 1904.
(98) *Essai sur l'Emploi Tactique de la Fortification de Campagne.* Paris and Nancy, 1906.
(99) "Fortification in its Tactical Application": *Professional Papers of the Corps of R.E.*, 1904. Chatham, 1905.

(100), (101). Other works are (102), (103), (104), (105). The work of the English engineers during the South African War is dealt with in (106) and (107).

The subject of mines is treated of by Lewis in (108). This book gives notes on the methods of arranging systems of mines and of fixing the dimensions of the galleries, and also deals with the use of so-called 'land mines.'

(*d*). ITALY.

The following works are of interest :—(109) and (110).

(*e*). AUSTRIA-HUNGARY.

We may mention (111), (112), and (113).

(*f*). ROUMANIA.

Various authorities deal partly with the actual construction of provisional and field fortification and partly with the different views held upon the subject. We may mention three articles in (114).

(*g*). RUSSIA.

Provisional fortifications are dealt with in (115); also in the text-book for the Nikolai-Ingenieurakademie (116), and its supplementary

(100) "The Duties and Work of a Field Company, R.E., with a Division fighting on the Offensive": *Professional Papers of the Corps of R.E.*, 1900.
(101) "The Blockhouse System in the South African War": *ibid.*, 1904.
(102) *Manual of Military Engineering*. Chatham and London, 1903. (The latest edition not in B.I.K.).
(103) "Field Engineering in the Light of Modern Warfare": *Jour. R.U.S.I.*, 1906.
(104) "With the Pontoon Troop in Natal, 1899 to 1900": *R.E.J.*, 1905.
(105) "Notes on Shelter Trenches": *ibid.*, 1906.
(106) *Mitt. des I.-K.*, No. 34. Berlin, 1903.
(107) Ditto. 37 Heft. Berlin, 1904.
(108) *Permanent Fortification for English Engineers*. Chatham, 1890.
(109) *Fortificazione Improvisata: Attaco e Difesa di Localita e di Posizioni Fortificate*, by Spaccamela. Rome, 1891.
(110) *Traccia per lo Studio della Fortificazione Campale*, by Rocchi. Turin, 1904.
(111) *Handbuch für Offiziere des Generalstabes*, by Springer. Vienna, 1897.
(112) "Der neue österreichisch-ungarische Kavalleriebrückentrain System Herbert": *M.W.*, 1904, and *Mitt. A.-und G.*, 1904.
(113) "L'Aerostation Militaire dans l'Armée Austro-Hongroise": *Rev. Mil. des A.E.*, 1905.
(114) "Einwendung eines Brückenkopfes in behelfsmässiger Befestigung"; "Bau einer behelfsmässigen Befestigung von Buzau," by Panaitescu; "Bau einer einfachen Brückenkopfbefestigung," by Rosu: *Memorial Geniului* (Bucharest), 1905 (B.I.K.).
(115) "Bombensichere Hohlbauten in provisorischen Befestigungen," by Engmann: *Mitt. A.-und G.*, 1899, page 656.
(116) *Gegenwärtiger Stand der ständigen und Behelfsmässigen Befestigung*, by Buinitzki. St. Petersburg, 1903.

volume (117). A comprehensive study of the subject is contained in (118). We may also mention (119), (120), and (121). Other branches of engineering are dealt with in (122), (123), (124), and (125). (126) also deals with the various technical implements of the two armies.

(*h*). SWITZERLAND.

See (127) and (128).

(*i*). JAPAN.

Military engineering in Japan is dealt with in (126), and also in (129) of the years 1904 to 1906 inclusive.

(*k*). THE UNITED STATES.

See (130) and (131).

P.—PROVISIONAL AND FIELD FORTIFICATION AND MILITARY ENGINEERING IN MILITARY HISTORY.

"Löbell's Jahresberichte" provide a record of the changes of view and procedure as they occur during each succeeding year. Krebs (132) gives information as to the arrangement and construction of provisional fortifications from the campaigns of 1864, 1870–71,

(117) *Kurzer Abriss des zeitgemässen Baues von Behelfsbefestigungen in den hauptsächlichsten fremden Staaten*, by Jakowiew. St. Petersburg, 1905.
(118) "Russische Anschauungen über Küsten-, Behelfs-, und Feldbefestigung nach der neuesten Literatur": *Mitt. des I.-K.*, No. 41. Berlin, 1906.
(119) *Schanzvorschrift für die russischen Sapeure*, by Tettau. Hanover, 1892.
(120) *Feldbefestigung*, by Kjui. St. Petersburg, 1895.
(121) "Flüchtige Befestigung der Gefechtsfelder": *Mitt. A.-und G.*, 1899.
(122) "Die Wirkung von Fugassengeschossen in Erde and Beton": *ibid.*, 1903.
(123) "Landminen bei den Russen": *K.Z.*, 1904.
(124) *Militärverkehrswesen*, by Krukow. St. Petersburg, 1903.
(125) "Taubenpost," by Hermann: *Russ. Ing. J.*, 1903.
(126) "Erfahrungen des russisch-japanischen Krieges": *Internat. Rev.*, 1906, Beiheft 73.
(127) "Kolonnenbrücken aus Notmaterial": *Schweiz. Zeit. für A. und G.*, 1904.
(128) "Das Licht im Dienste des Heeres": *ibid.*,
(129) *Mitt. A.-und G.*, *K.Z.*, and *Streffleur.*
(130) *Field Fortification and Field Engineering*, by Fiebegger. West Point, 1899.
(131) "The Operation and Maintenance of a Railroad in a Theatre of War": *Jour. M.S.I.*, 1905.
(132) *Kriegsgeschichtliche Beispiele der Feldbefestigung und des Festungskrieges.* Berlin, 1901.

1877–78, as well as historical examples of the employment of field fortification and other branches of military engineering. All kinds of work, from the least, such as the clearing of fields of fire, to the most comprehensive, such as the organisation of the defence of localities and extensive positions in the wars of 1864, 1866, 1870–71, are dealt with. The construction of roads and of railways, of bridges and ferries, of signalling apparatus and hutments, is discussed, with the aid of examples taken from campaigns of the most varied character.

Wagner (1) deals with the provisional fortifications of Torres Vedras, those on the Nuthe and Notte in 1813 and 1866 and at Dresden in the same years, those of Floridsdorf in 1866 and of Mannheim in 1870, taking special care to show what was aimed at and what was actually attained in each case. An instructive comparison can be made between this work and (133), by Gizycky, on account of the discussion in the latter book of the method of fortifying the segment formed by the Nuthe and Notte with field works.

Deguise (24), besides discussing the historical examples of provisional fortifications mentioned by Wagner (1), also takes other instances from the war of 1870–71 and refers to Plevna. In this book he first gives a very comprehensive historical review, in which he mentions, among other things, the close connection which has always existed between the fighting efficiency of an army and the means of communication between localities.

Weiss (38) deals briefly with particular battles and engagements, and with the constantly diminishing proportion borne by the garrison of a position to its extent. He points out, for instance, that this was as much as 11 men to the mètre at Königrätz and only 1½ men to the mètre on the Lisaine.

Historical examples are given by Stavenhagen (3), Schroeter (5), Rehm (9), and Philips (42). We may also refer the reader to (134) and (135). (136) and (137) give notes, founded on the experiences of history, as to how the demolitions referred to should be carried out.

(133) *Strategisch-taktische Aufgaben nebst Lösungen.* Heft 13. Leipzig, 1900.
(134) "Plewna, Schipka, Sebastopol; eine Studienreise," by Schwarte: *M.W.*, 1905, Beiheft, p. 45.
(135) *Die Festung in den Kriegen Napoleons und der Neuzeit. Studien zur Kriegsgeschichte und Taktik.* Vol. 4. Berlin, 1905.
(136) *Brückenzerstörungen im Rückzugsgefecht einst und jetzt*, by Scharr. Berlin, 1902, and *K.Z.*, 1902.
(137) "Die Zerstörung der Eisenbahnen im Kriege," by Rayle: *Jahrb. für A. und M.*, 1906.

PART IV.

COAST WARFARE AND COAST DEFENCE.

A.—GENERAL.

Just as in land warfare the destruction of the enemy's Army, so in naval warfare the destruction of the hostile Fleet is the main object to which all other considerations must be subordinated.

The destruction of the hostile Fleet assures the command of the sea and therewith the possibility of destroying the seaborne commerce of the enemy and of obtaining possession of his Colonies, provided that these latter have not at their command strong forces of their own. Further considerations with regard to the effect in warfare of operations at sea are to be found in (1).

The defeat of the enemy's main seagoing Fleet, however, always marks the time when operations against the hostile coast can be really effectively undertaken (2).

The extent of these Coast operations depends principally upon the means at the disposal of the victor at sea. They may vary in degree, from small undertakings calculated to disturb the enemy's harbours, to the destruction by bombardment of wealthy towns on the coast or the landing of small or large portions of the army.

Since even the greatest Sea Power cannot depend upon gaining complete success at sea under all circumstances, all States have established Coast Fortifications with the object of making the chances of Coast Warfare as favourable as possible to the side which is outmatched on the high seas.

B.—THE RÔLE OF COAST FORTIFICATION.

Leithner (3) points out that Coast Fortifications cannot alone ensure the safety of the coast, for they can only act as supports for the Army and the Fleet. To the two latter falls, in the first place, the task of protecting the Coast. According to Leithner, coast fortifications should be used to secure naval harbours as bases for the fleet, and to block arms of the sea, etc., whilst leaving them open to the use of one's own navy. Besides fulfilling these tasks they should

(1) *Krieg-und Heerführung*, by von der Goltz. Berlin, 1901.

(2) "Immer das Moment, welches die Ausführung eines wirkungsvollen Küstenkriegs am wesentlichsten erleichtert," quoted from the *Memoir for the German Fleet*, 1887–88. See "Über Küstenverteidigung," by Stavenhagen, *Mitt. Seewesens*, 1902.

(3) *Die Küstenbefestigung*. Vienna, 1894.

be used to guard specially favourable anchorages, depôts, and commercial harbours.

According to Didelot (4), coast fortifications should be used for the defence of harbours, arsenals, roads, and passages, and also of such points inland as command these places or the approaches to them.

Mellichhofer (5) regards the task of coast fortifications as that of forming points of support for the fleet. The latter is constantly in need of such places as bases for its operations. Ships can be built and equipped there, can there find a safe refuge and the means of refitting if they have sustained damage at sea. These bases should be able to supply all the necessaries required by the fleet.

Foss, in his comprehensive work (6), says that the best protection for a coast is a strong fleet on the high seas; but he adds that certain causes make it necessary to have means of defence independent of the fleet, and hence the need for coast fortifications. These should be situated especially at those points injury to which would be most to the disadvantage of one's own fleet, that is to say at naval harbours. Places which also need protection by fortification are :—Bases for the fleet (other than the above), large commercial harbours, points of strategical importance such as the mouths of canals, etc. The safe possession of depôts and points of support in every sea is of the greatest importance. It makes a fleet more independent and more mobile, for it does away with the necessity of sailing in company with a large number of vessels of no fighting value. A confirmation of this view is to be found in the experiences of Admiral Rodjestwenski during the War in the Far East in 1905.

Wachs (7) takes as his text the sentence, "He who has command of the means of carrying on the commerce of a country also commands that country itself," and demonstrates the value of points of support to a Fleet. Frhr. v. Maltzahn (8) points out that Points of Support are also necessary if one adopts the method of Cruiser Warfare, which consists in attacking the opponent's commerce and protecting one's own.

In the article (9) the opinion is expressed that to-day more than ever suitable supporting points are necessary for the conduct of oversea enterprises. It goes into the question of how far the ships can be made independent of such points of support, and gives much

(4) *La Défense des Côtes d'Europe.* Paris and Nancy, 1894.
(5) *Der Küstenkrieg.* Vienna, 1903.
(6) *Der Seekrieg.* Berlin, 1904.
(7) "Die englischen Etappenstrassen von Grossbritannien über die canadischen Dominion nach den westlichen Häfen des Pacific und nach Indien": *Mar. Rund.*, 1903.
(8) "Das Meer als Operations-und Kampfeld": *ibid.*, 1904.
(9) "Die Abhängigkeit der modernen Kriegsschiffe von Ausrüstungsplätzen, insbesondere die Bekohlungsfrage": *Nauticus* (Jährbuch für die deutschlands Seeinteressen), Berlin, 1902.

interesting information as to the various methods of carrying out that operation which is of such importance to the efficiency of warships, namely coaling in harbour or at sea.

Coaling Stations and their organisation are discussed in (10). It is claimed for these places that their buildings and anchorages should be safe from bombardment. It is considered that such a bombardment could be carried out at ranges of from 13 to 15 kilomètres (8 to 9 miles), as no great accuracy in aim would be required. In order to keep hostile ships beyond this distance, recourse must be had to fortifications. The paper in question goes on to treat of such works more closely, and to deal with various natures of Landings and with the general scheme of construction of fortified coaling stations.

The article (11) says that even so strong a sea power as England requires coast fortifications in order to make the fleet independent, and also to protect its bases and the most important places on the coast in case the command of the sea should be lost even for a time. The paper (12) dwells upon the importance of relieving the fleet of any anxiety as to the protection of its points of support. This "setting free" of one's fleet by the use of suitable coast fortifications is also brought forward in (13), where, speaking of the state of the war at the time of writing, the author says that the sea forces of both sides would constantly be reinforced by the help of their fortified naval harbours. In this connection the importance of coast defences in the offensive undertakings of the Fleet is clearly shown. The work (14) says, when discussing the Sieges of Danzig and Kolberg in 1807, that great fortified harbours form as it were "sally ports" for a defender who has command of the sea. Stavenhagen (15) expresses himself to much the same purpose.

Whilst the majority of the writers hitherto referred to look upon obtaining command of the sea as the necessary preliminary to undertakings against hostile coast defences, Henning (16) comes to another conclusion which he bases upon the experiences of history. He considers that no fleet, however large, can keep an effective watch upon the movements of a determined enemy; and that even when opposed by a superior sea power, a fleet will be able to operate

(10) "Befestigte Kohlenstationen": *Russkii Invalid*, 1899; extract in *Mitt. A.-und G.*, 1900.
(11) "Coast Defence": *Jour. U.S. Art.*, Nov. and Dec., 1904.
(12) "The Land Defence of Coast Defences": *ibid.*, July, Aug.,.
(13) "Küstenbefestigungen mit besonderer Rücksicht auf Ostasien": *Überall*, 1903-04.
(14) *Die Festung in den Kriegen Napoleons und der Neuzeit. Studien zur Kriegsgeschichte und Taktik.* Vol. 4. Berlin, 1905.
(15) "Über Küstenbefestigungen": *Deutschland Monnatsschrift für deutsche Kultur.* Berlin, 19'5 (B.I.K.).
(16) *Die Küstenverteidigung.* Berlin, 1892. A continuation of *Unsere Festungen.*

against the hostile coasts. In this fact he sees a strong reason for protecting the coast with suitable fortifications.

According to a saying of Burke, quoted by Clarke (17), the freedom of manœuvre of the fleet depends upon the security of the coal supply and upon the control of suitable harbours. In order to ensure this security, the first requisite is Command of the Sea, the second suitable fortifications for the defence of Bases for the Fleet and of Naval Harbours.

In (18) May holds that the construction of coast fortifications is only justifiable in cases where their existence will tend to give freedom to the fleet.

The arrangements for defence cannot be understood without a knowledge of the means of attack which may be expected to be used against that defence. In the following pages, therefore, the details of Coast Warfare will be dealt with before those of Coast Defence Fortifications.

C.—MEANS OF ATTACK.

ATTACK FROM THE SEA. WARSHIPS IN GENERAL.

According to the method of distribution adopted in Germany, the ships which would participate in operations from the sea may be generally classified as follows :—Battleships, Armoured Coast Defence Vessels, First Class Cruisers (grosse Kreuzer), other classes of Cruisers (kleine Kreuzer), Gunboats, Destroyers, Torpedo Boats, Submarines, Training Ships, and Special Service Ships (Schiffe für besondere Zwecke). More detailed information as to the different classes of ships and representatives of each is to be found in (19) by Helm, and in (20) by Weyer.

Information as to the present establishment of the German Fleet and that foreshadowed by the Bill of June 14th, 1900, and as to the increase in the size of torpedo-boats, is given in *Die Marinevorlage*, 1906, and in (21).

For the purpose under consideration the armament and structural peculiarities of the warships of various natures are of special importance. Among these factors may be mentioned the number and nature of guns and torpedoes carried, the armour, speed, and turning capacity, the arrangements for external illumination and observation, and finally the special attributes of submarines. (22), by Wahl, gives a comprehensive review of the means of making war at sea.

(17) *Imperial Defence*. London, 1898.
(18) *Principles and Problems of Imperial Defence*. London, 1903.
(19) *Die deutsche Marine nach dem Flottengesetz von 1898*. Berlin, 1898.
(20) *Taschenbuch der Kriegsflotten*. Published annually.
(21) "Bemerkungen zur Flottennovelle und Denkschrift zum Etat 1906": *Mar. Rund.*, 1905.
(22) *Der moderne Seekrieg und seine Kampfmittel*. Reval, 1904.

D.—NAVAL GUNS.

"The gun power of a ship has become its predominant and most effective weapon of Offence," says Mielichhofer (5). He divides the artillery equipment of a ship into the main and the secondary armaments, whilst we are more familiar with the expressions heavy, medium, and light artillery.

Leithner (3) says that, at the time of writing, mortars (or howitzers) were never included in a ship's armament, thereby calling attention to a point of great importance in coast warfare. It must be left undecided whether, in the course of time, ordnance capable of high angle fire will be employed to any extent on board ship. Various reasons why this is not likely to be the case are given in (5). Leithner also deals with the methods of fire used at sea, and says that the gunnery training is mainly directed towards delivering a rapid fire against moving targets which are not at long ranges but are at the same time of large size. He concludes, therefore, that a heavy "mass" of fire may be expected from the guns of warships, but no very accurate fire.

The paper (23) deals with the details of the latest naval guns, particularly with their power of penetration, accuracy, and rapidity of fire. The general conclusion is arrived at that common shell should be fired from quick-firing guns and armour-piercing shell from the heavy guns.

Foss (6) briefly discusses naval guns and gives some interesting results of shooting taken from naval warfare. According to these figures, only 2½% of hits were obtained in the battle of Santiago de Cuba, on July 3rd, 1898, by the large American ships against the Spanish cruisers. Even this small percentage included the hits obtained upon the superstructure.

The article (24) concludes, from the results of a number of bombardments of recent years, that there is very small likelihood of well armed and constructed land fortifications being overcome by ships' guns. He thinks that Moltke's saying—"Man kann sich hinter einem Steinhaufen eine ganze Zeit verteidigen, wenn man nur Lust dazu hat" (one can hold out quite a long time behind a heap of stones, if one cares about it)—can be equally well applied to coast warfare. Interesting data as to probability of hitting and powers of penetration are to be found in (25).

(23) "Die Fortschritte in der Entwickelung des Schiffspanzers und der Marineartillerie im Jahre 1902": *Mitt. Seewesens*, 1903 and 1904.

(24) "Munitionsverbrauch von Schiffen bei Beschiessungen": *N.M.B.*, 1903.

(25) "Erd- oder Panzerschutz für Küstenbefestigungen," by Stavenhagen: *Mar. Rund.*, 1903.

everything which has been written upon the subject in France, England, Germany, and the United States. This preface is also interesting owing to the high degree of importance which it attaches to these weapons in connection with the defence of the French coast. It says that they would make a blockade of the coast impossible, and would threaten hostile British squadrons, even in their own naval harbours. Possibly this expression of opinion is connected with the great interest which is displayed in France in the further construction of submarines.

Yet another French book (37) goes very closely into the question of mines, torpedoes, torpedo boats, and submarines. Mines, described as the most-to-be-feared guardians of the coast, and the means of rendering them harmless are dealt with. The other weapons above referred to are also well described with the aid of sketches.

An article in (38) contains information regarding the Bliss-Leawitt torpedo, which is said to have been introduced in the United States and to be very effective in its action.

The mine is primarily a weapon of the defence. The attacker may use these weapons for destroying obstacles, *e.g.* a sunken ship, or to close the exit from a hostile harbour, etc. He can also use his own mines to explode those of the enemy which may be forming an obstacle to his movement.

Mielichhofer (5) distinguishes between Contact and Observation Mines, and gives general descriptions of both.

Brialmont (30) speaks of Electric, Electro-Automatic, and simple Automatic Mines, and discusses the advantages and disadvantages of each.

Interesting comparisons as to the effects of submarine explosions are to be found in (39) and (40). These effects fall off very rapidly as the distance between the objective and the point of explosion increases. For instance, a charge weighing 100 kilograms (219 lbs.) of an explosive gives ten times as great a blow on a unit of surface when in immediate contact with that surface as when it is at a distance of 150 mètres (164 yards) from it. This fact points to the desirability of forming a ship's bottom of several walls, so that an explosion against the outer wall would not affect the inner one. To what extent the latest ideas upon the subject of ship construction will be influenced by this fact, combined with the lessons of the late war in the Far East, is not to be gathered from the treatises in question. Some information on this point can be obtained from (41).

(37) *L'Électricité et la Défense des Côtes*, by Dary. Paris, 1894.
(38) *Jour. R.U.S.I.*, February, 1906.
(39) "Unterwasserpanzer": *Mar. Rund.*, 1904.
(40) "Unterseeische Explosionswirkungen": *Sprengstoffe, Waffen und Munition (Zeitschrift)*, 1905.
(41) "Torpedo und Mine im Seekriege": *Nauticus*, 1905.

F.—SUBMARINES.

To the means of operating under water against the ships of the defence and against obstacles placed in the fairway must be added Submarine Vessels (or Submarines, as they are usually termed).

A thorough review of the question of Submarines as it existed in 1902 is to be found in (42), whilst the subject is briefly dealt with in (43). In (44) Stubenrauch discusses the Submarines proper and "Diving Boats" (Tauchboote) as they were then, and the uses to which submarines could be put for war purposes.

The article (45), taken from the *National Zeitung*, gives the numbers of submarines in the year 1904. In (46) the use of submarines in a blockade is thoroughly gone into, and the conclusion arrived at that they would not be of any value to a blockader. The articles (47) and (48) warn us against placing too much confidence in this new weapon. In the latter article the author discusses the technical side of submarines, their method of use in attack under the most varied circumstances, their employment in reconnaissance and for locating booms or obstacles and cables, and the measures necessary to ward off their attacks. It has already been said that submarines are dealt with in (37).

The article (49) gives a review of the state of advancement of these boats in different countries and of the development of the various types. It also deals with the demands which can be made upon them in war time, and with the experiments which have been made in this connection. The power of seeing under water has not really been improved during the last few years, in spite of the introduction of periscopes and hyphydroscopes. All the qualities of these vessels, as well as their small radius of action (which does not exceed 50 sea miles), lead to the conclusion that they will not really be of use except in the neighbourhood of the coast, and probably only on the side of the defender. They will not be the cause of a revolution in the methods of conducting warfare at sea. They are far behind what is required in the principal attributes for war—power of vision, speed, radius of action, and seaworthiness.

(42) "Die Unterseeboote der Gegenwart": *Nauticus*, 1902.
(43) "Neue Unterseeboote": *Streffleur*, 1903.
(44) "Unterseeischer Angriff": *K.Z.*, 1903.
(45) "Les Sous-Marins des Principales Puissances Maritimes": *Internat. Rev.*, 1904, Suppl. 64.
(46) "Die Preisarbeit des englischen Leutnants A. C. Dewar, R.N., über die Kriegsblockade unter Berücksichtigung der modernen Kampfmittel": *Mar. Rund.*, 1904.
(47) "Deutsche Unterseeboote": *Überall*, 1904–05.
(48) "Verwendung und Abwehr von Unterseebotten": *ibid.*,
(49) "Der heutige Stand der Unterseebootsfrage": *Nauticus*, 1904.

The development of submarines is also dealt with in (50), which will be referred to again.

G.—THE ARMOUR OF SHIPS.

Mielichhofer (5) considers that battleships should be able to withstand the projectiles of the heaviest and largest guns; and holds that all the portions of these ships which are necessary to their fighting efficiency—guns, ammunition magazines, engines, conning towers, and steering apparatus—should be protected by strong armour. On the other hand, he is of opinion that the armouring of cruisers should be much reduced in extent. He also gives some information as to the effect of gunfire against armour, and is in favour of an armoured belt of hardened nickel steel of an average thickness of 250 m.m. (10″)

Leithner (3) expects battleships as a rule to have an armoured belt and an armoured deck, besides armour for the special protection of guns, commanders' stations, etc. He gives the ranges at which various thicknesses of wrought-iron armour plates (the book was written in 1894) would be penetrated by the 28-c.m. (11·2″) gun; and, for various reasons, does not anticipate that the proportions given by him will be changed by the introduction of newer and stronger materials for armour, such as nickel steel and harveyised plates.

To what extent this opinion was justified will be seen by studying the latest works on armour and the effect of projectiles. We may here remark that the accuracy of all data as to the effects obtained by projectiles against armour should be most carefully tested before being accepted, for the composition and method of construction of the plates are practically the deciding factors. In this connection it is interesting to note that, according to Foss (6) plates manufactured abroad on Krupp's patent are some 10% weaker than those made at Essen. Foss also gives some short notes upon the development of armour, its use in various forms of ship-construction, and the results of firing at armour.

(51) gives data as to the effect of capped projectiles upon armour plates, whilst (52) shows how the present form of capped projectile was arrived at, and how its efficacy is accounted for. The penetrations obtained with a number of armour-piercing projectiles are given in tabular form. Further statements on the subject of the above article are contained in (27), where stress is laid upon the importance

(50) "Das Unterseeboot; ein geschichtlicher Rückblick": *Prometheus*, 1906.

(51) "Einiges über Schiffsartillerie, Torpedos und Seeminen in der französischen Marine": *Mar. Rund.*, 1905.

(52) "Die Wirkungsweise bekappter Panzergranaten": *Mitt. Seewesens*, 1905.

of preserving the engines of a ship if it is to remain capable of fighting; and the remark is made that, in trying to obtain the best protection for the engines, it is impossible to have too much of a good thing (des Guten gar nicht zu viel getan werden kann). In connection with armoured decks, it is said that the present tendency is to try and reduce their thickness. This tendency again shows us that battleships are primarily constructed with a view to battles at sea, in which high angle fire is not to be expected. The articles (28) and (29) deal, among other things, with the powers of penetration of projectiles at different angles of impact, and with the total amount of protection for the engines obtained in the case of the ship which is taken as an example, both when she is on an even keel and when she rolls.

Details as regards armour are given in the book mentioned under E in Part II.

Finally we may call attention to (53), in which it is said that, according to the experiences of the war in the Far East, the value of ship's armour has decreased.

H.—DETAILS OF SHIPS.

THE SPEED, TURNING CAPACITY, RADIUS OF ACTION, BULKHEAD DISTRIBUTION, AND DRAUGHT OF WARSHIPS. SEARCHLIGHTS AND COMMUNICATION.

See also Part III.

Their speed enables warships, in coast warfare, to appear unexpectedly, to withdraw again rapidly out of range of the coast defences, and finally to make it very difficult for the guns of these defences to hit them. The latter advantage is much increased by good turning capacity and the consequent power of frequently altering course. These attributes are dealt with in (2), (3), (5), (6), and other books.

The bulkhead distribution, or arrangement of the watertight compartments, which serves to localise the influx of water caused by a leak at any point; the radius of action, which means the distance a ship can travel without re-coaling; and the draught of warships, which is often a point of great importance in connection with their use in coast warfare, are all dealt with in (6) among other works.

Searchlights, see (5), serve to illuminate the neighbourhood of a ship and thereby to prevent the unobserved approach of hostile vessels. Foss (6) also discusses the question of where the searchlights should be placed on board ship, and gives a short comparison

(53) "La Faillité du Cuirassé": *Revue Maritime*, 1904.

between their use on land and at sea. The paper (54) contains a popular account of the subject with special regard to some forms of illuminating towers (Leuchttürme). In (55) some interesting observations are made as to the influence of searchlights in night operations on land. (56) should also be noted in this connection.

Communication within the ship with other vessels and with stations on the coast, as far as signalling is concerned, will not be dealt with here at length, but the reader is referred to (6).

The question of wireless telegraphy in the navy is dealt with in the articles (57) and (58). The latter, whilst fully alive to the merits of this means of communication, does not disregard its deficiencies from the service point of view, especially with respect to the fact that its messages can be read by others besides those for whom they are intended. It is also pointed out that the distance at which signals can be read between ships is somewhat limited—from 70 to 175 kilomètres (44 to 109 miles) at most.

Nauticus, 1900 to 1904, gives information as to another important means of communication by sea, namely Submarine Cables.

J.—ATTACK FROM THE LAND. SEA TRANSPORT AND LANDINGS.

See also Part III.

The Boer War, the events of 1900 in Eastern Asia, the war between China and Japan, and that between Japan and Russia, the measures taken to suppress the rising in S.W. Africa, as well as various political events, have lately brought into prominence the question of the transport of troops by sea.

Transport of this kind is dealt with in (59), which, after a short historical retrospect, treats of the fitting out of an Expeditionary Corps, the conditions of transport, the carrying capacity of transports, the accommodation of troops on board, the method of landing and the time taken in the process. (60) gives details as to means of transport and the method of dealing with it, and as to the means of carrying out disembarkations.

Foss (6) deals with transport by sea and refers to Number 7 of

(54) "Elektrische Scheinwerfer im See- und Heereswesen": *Überall*, 1904–05.
(55) "Searchlights in recent Night Operations at Chatham": *R.E.J.*, 1905.
(56) "Die Elektrizität im Dienste der Armee und Marine": *K.Z.*, 1903.
(57) "Die Funkentelegraphie in ihren Bedeutung für die Kriegs- und Handelsmarine": *Nauticus*, 1901.
(58) "Die Fortschritte der Funkentelegraphie und ihre Bedeutung für den Verkehr": *ibid.*, 1904.
(59) "Überseeische Expeditionen": *ibid.*, 1901.
(60) *Taschenbuch für den Pionieroffizier*. Berlin, 1904.

Die Marine Rundschau, 1898, in which it is stated that 28 large steamers of 85,000 tons would be required for the transport oversea of one infantry division. Almost in agreement with these figures, Mr. Balfour, speaking as Prime Minister in the English House of Commons on May 11th, 1905, stated that the army of 70,000 men, which he estimated to be necessary for an invasion of England, would require a fleet of transports with a tonnage amounting to 250,000 tons, and that the landing of this force would take 48 hours. Mielichhofer (5) deals with the difficulties attendant upon landings, and gives sketches of boats intended for use in the disembarkation of men, horses, and ammunition.

According to *Streffleur*, 1905, page 1629, the "*Borussia*" has been built with the express object of carrying troops. She is to carry 1,400 dismounted men with the necessary transport and equipment.

(61) is concerned with the transport of horses by sea.

The importance of oversea expeditions for England has led to prizes being offered in that country for papers on the subject of "The best method for carrying out the conjoint practice of the Navy and Army in Embarkation and Disembarkation for War." The two articles which gained the first two prizes (62) discuss a large number of undertakings of this kind taken from history, enquire into the causes of failures, and contain instructive lessons as to the necessary organization, the co-operation of the different authorities, the preparation of transports and landing places, and the tactical conduct of landings. The disembarkation on the Essex coast in the manœuvres of 1904 is dealt with.

The technical work carried out in connection with the above-mentioned landing operations is fully dealt with in (63).

(64) deals with the Prize Essays just mentioned. A historical review of landings carried out in past wars is given by Hummel (65). The paper (66) treats of the work carried out during the Anglo-Boer War. Co-operation between the army and navy and some details as to transports and disembarkations form the theme of (67) by v. Janson, (68) by v. Edelshein, and (69).

(61) An article taken from the *N.M.B.*, entitled "Le transport des chevaux sur Mer": *Internat. Rev.*, 1905, Suppl. 75.

(62) *Jour. R.U.S.I.*, 1905.

(63) "Landing Operations at the Essex Manœuvres, 1904": *R.E.J.*, 1905.

(64) "Über Landungen": *M.W.*, 1905.

(65) *Landungen und ihre Abwehr*. Vienna, 1902. Referred to in *Mitt. A.-und G.*, 1902.

(66) "Der überseeische Transport des südafrikanischen expeditionskorps": *N.M.B.*, 1900.

(67) *Das strategische Zusammenwirkung von Heer und Flotte*. Berlin, 1900.

(68) *Operationen über See*. Berlin, 1901.

(69) "Das taktische Zusammenwirkung zwischen Heer und Flotte": *Mitt. Seewesens*, 1905.

K.—MEANS OF DEFENCE.

GENERAL.

It will be seen by a study of the above-mentioned works that Coast Defences have to deal with an enemy who can, possibly before or simultaneously with the declaration of War, bring into action, very rapidly and unexpectedly, flat trajectory guns of all sizes mounted on board ships which possess high speed and turning capacity. The accuracy of shooting of the ships' guns will be adversely influenced by the movement of the ships, and their supply of ammunition is limited. The ships offer a good target, and their near approach to the coast will under certain circumstances be stopped by their deep draught.

The attacker can make use of torpedoes, mines, and submarines, and attempt to enter the mouths of harbours, rivers and canals. He is finally in a position to operate against the coast defences from the land side, with a larger or smaller force according to circumstances.

The consequent steps to be taken in the matter of establishing and arming coast defences are dealt with in, among other works, (70) and (71), the latter by v. Brunner.

L.—COAST ARTILLERY.

The tasks of Coast Artillery are divided by Mielichhofer (5) into its action against (*a*) large battleships, (*b*) against unarmoured or lightly armoured ships of large size, and (*c*) against small vessels. Whilst holding that the artillery armament of coast works must be of a stable nature for reasons of security, he shows the disadvantages as well as the advantages of this stability.

Rangefinders and the methods of using coast artillery under all kinds of conditions are discussed in this book.

Brialmont (30) would equip coast defences with heavy guns, howitzers and mortars, and quick-firing guns of medium and small calibres.

Grasset, in his comprehensive work (72), distinguishes between batteries for use against the main attack, those for the artillery fight, mortar batteries, and batteries of light guns. The batteries opposing the main attack have to hold up the attacker in the entrances or passages which they defend. They will only be able to fire a few shots at a ship running past at high speed, and their artillery must

(70) *Leitfaden für den Unterricht in der Befestigungslehre, im Verkehrswesen und im Festungskrieg auf den Königlichen Kriegsschulen.* Berlin, 1906.
(71) *Leitfaden für den Unterricht in der ständigen Befestigung.* Vienna, 1856.
(72) *La Défense des Côtes.* Paris and Nancy, 1899.

therefore be of such calibre as to ensure that the projectiles will be able to penetrate the armour at the longest ranges attainable. The batteries destined for the artillery duel must endeavour to keep hostile ships at a distance from the coast. Grasset therefore claims for these batteries a large number of guns and an ample supply of ammunition. He thinks, however, that the projectiles from these guns cannot be expected to penetrate armour, owing to the very long ranges at which they will usually be fired. The effect of mortar batteries against moving targets is not estimated at a high figure. The batteries of light guns are intended for use against the lighter natures of ordnance on the ships, which they should silence, and against the unprotected portions of the ships.

Stavenhagen (73) says that what are wanted for this purpose are very effective and rapid firing guns with large fields of fire open to them. They should offer a small target to the enemy, be well provided with cover, and be in a state of constant readiness. He discusses various natures of guns, and briefly deals with the more important coast artillery guns of the principal Powers.

Leithner (3) treats of the artillery armament of coast works according to the various tasks which have to be fulfilled by them, and touches upon the question of mountings and ammunition supply. Foss (6) calls attention to the value of high-sited batteries for obtaining effect against ships.

In (74) it is pointed out that it is unsound to trust to the thickness of walls alone, but that the best protection is to be found in well-conducted, accurate, and concentrated fire. This paper lays special stress upon the value of direct fire, without altogether condemning the indirect method.

The duties of coast artillery acting against attacking ships are also dealt with in (2) and (11). The latter paper holds that the projectiles of the heavy guns should be capable of reaching the vital parts of a hostile ship, her engines, etc., at the longest possible range, and considers that the 12" gun is required for this purpose. The medium guns should be able to penetrate 6 inches of armour, whilst the lighter guns will be mainly used against torpedo-boats.

For information as to the firing of guns by electricity see (37).

Further details as to the ballistics, disposition, etc., of coast guns are to be found in most of the writings referred to under subheads D and G of this Part. Gun mountings, the arrangements for supplying ammunition, and other questions closely connected with the provision of cover, are referred to when the latter subject is dealt with.

(73) "Über Küstenartillerie": *Mar. Rund.*, 1902.
(74) "Wer ist stärker, der Kriegsschiff oder die Küstenbatterie": *Streffleur*, 1901.

M.—BOOMS.

AND OTHER FORMS OF OBSTACLES (SPERREN).

The following notes are in addition to what has been said under subhead E.

Foss (6) compares booms and the like with the obstacles placed in front of land fortifications; and holds that they should make the navigation of a channel impossible for hostile ships, bring the latter to a halt at a desired point, or at least cause them to move very slowly. The boom or other barrier should, of course, be commanded by the guns of the defence, and its presence should considerably enhance the strength of a position for artillery. Foss mentions mine barriers, barriers of sunken ships, and "torpedo batteries," and gives instructions as to how the two former may be rendered ineffective.

Mielichhofer, when discussing obstacles on land, also deals with sea barricades, sunken ships, chains stretched across the channel, etc., as well as with torpedo batteries. Leithner (3) says that minefields should never be left undefended, and that it is best to arrange for their being commanded by a battery on the flank. Stavenhagen also (15) would have the several blocking arrangements of a harbour barricade protected by torpedo batteries or by the guns of the works. The same writer points out (2) that the question of submarine defence must be worked out before the coast defences can be planned; and remarks that booms can never take the place of forts and batteries, if only because their construction is dependent on the weather and may be rendered impossible by a storm at the most critical moment. Brialmont (30) and Grasset (72) deal with various forms of booms and barricades and with torpedo batteries.

N.—SHIPS.

The power of resistance of coast fortifications is of course greatly increased by the co-operation of warships, be they submarines, torpedo boats, or larger vessels. Works which deal with this kind of co-operation have been mentioned under subheads U to W. As to the particular features of the ships in question and their disposition for this purpose see subheads C, D, F, G, and H.

O.—COAST FORTIFICATIONS.

METHODS OF CONSTRUCTION ON THE SIDE FACING THE SEA. EQUIPMENT AS REGARDS RANGEFINDERS, SEARCHLIGHTS, BALLOONS, AND MEANS OF COMMUNICATION.

See also Part III.

As in all branches of war, so in coast warfare the saying "Effect before Cover" (Wirkung geht vor Deckung) holds good. In this sense Stavenhagen (25), after discussing the effects obtained with coast defence guns and the probability of making hits with them, lays stress upon the necessity of these guns being in a high state of readiness for action, of their having the requisite extensive field of view, and of their mountings being easy to work. He considers fire over the parapet the best for effect in the case of open earthworks. He discusses the question of cover from the points of view of tactics, technical considerations, military history, and political economy. He deals in particular with disappearing mountings and the different ways of applying the use of armour, and gives proposals for various ways of placing guns in position with reference to direct and high-angle fire.

Foss (6) tells us that, according to the experiences of the War of Secession, casemates of masonry were not strong enough to withstand naval guns, whilst earthworks answered better. England, therefore, turned to the use of armour for her new coast defences, as the construction of the latter was too far advanced to admit of introducing stronger earth cover to any considerable extent. The successful expedient of concealing portholes by painting the outside of a fort so as to make it resemble the squares of a chessboard is also mentioned. This work also deals with Gruson's armoured turrets, French casemates, and disappearing mountings (see also Part II.).

Leithner (3) is in favour of placing guns and their detachments under armoured shelters, which, under certain circumstances, would be increased in size so as to form towers completely closed and stronger to hold. He deals with the usual types of coast fortifications from the point of view of gun positions, and with the details of coast batteries and coast forts. He also refers to Brialmont's proposals in (75).

The latter writer (30) makes us acquainted with a number of points to be observed in the planning of coast batteries. Among these may be mentioned :—Avoid accumulating in one place possible targets for the enemy's fire ; avoid placing guns in front of masonry or rock ; construct earthworks of light soil or pure sand ; make an armoured observation station, and have a searchlight in every large work ; arrange for every part of a work to be well lighted ; provide cover for guns intended to command booms, etc. The book gives types of forts and batteries suitable for use on the coast itself, in the sea, or on an island. It further describes all kinds of mountings, armoured casemates, and armoured turrets, and in every case tells us where they have been constructed in different countries. It deals with the fortification of the Bosphorus and the Dardanelles at the time of writing, and gives proposals for the rebuilding of those works. Of the subjects treated of in this book we would particularly call attention

(75) *Fortification du Temps Présent.* Brussels, 1885.

to the results obtained when firing at Krupp's nickel steel plates in December, 1894, and March, 1895.

Stavenhagen in (76), and in (70) and (71), deals with the detailed arrangements of coast fortifications.

In (77) Schroeter says that heavy coast guns are little suited for defence at close ranges; but that different opinions may be held as to whether, and if so how, these guns can be given protection against a close attack. In the course of his observations he comes to the conclusion that closed coast forts should only be used in exceptional cases, at points which are specially threatened, *e.g.* on the flanks of sea fronts, where these join on to the land fronts of a fortified place, or in places where space is limited.

In (78) Rocchi discusses the details of the construction and disposition of coast works, and also makes some observations upon the means by which the navy can assist in coast defence. Deguise, in (79), devotes some space to coast fortifications. The article (80) gives, with the aid of sketches, very complete information concerning these mountings (*i.e.* disappearing mountings).

According to Mielichhofer (5) it is especially important, in view of the rapid movements of a modern fleet, to be able to measure ranges rapidly and thus avoid the tedious process of ranging. Among range-finders for this purpose, the book in question mentions that of Barr and Stroud; besides this an automatic sight is described. The author fully explains the importance of properly identifying an enemy's ship, and of correctly estimating the speed with which she is moving and the angle of impact; and investigates the means at the disposal of the coast artillery for solving these problems.

For a closer study of the subject the reader is referred to (81) and (82). Finally we may mention (83) and (37).

Sources of information upon the subject of Searchlights are given under subhead H of this Part.

As to the use of Balloons in conjunction with fortifications we may refer to Parts III. and V.

Mielichhofer (5) requires an extensive installation of telephones and telegraphs, and divides these generally into those for fortress use

(76) *Grundriss der Befestigungslehre.* Berlin, 1900.
(77) *Die Festung in der heutigen Kriegführung.* Berlin, 1903 and 1905.
(78) *Traccia per lo Studio della Fortificazione Permanente.* Turin, 1902. Extract in *Mitt. A.-und G.*, 1903.
(79) *La Fortification Permanente, appliquée à l'Organisation des Forteresses à Grand Developpement.* Brussels, 1896.
(80) "Verschwindlafetten": *K.Z.*, 1902.
(81) "Zur Theorie der Küstendistanzmesser mit vertikaler Basis": *Mitt. A.-und G.*, 1902.
(82) "Das Schiessen aus Küstengeschützen": *Streffleur*, 1903.
(83) "Entfernungsmesser und Fernrohre in militärischer Hinsicht": *Prometheus*, 1905.

and those for artillery purposes, including those for coast observation stations and signal stations. Foss (6) says that the individual works and obstacle stations (Sperrstationen) are connected with the central control station (Fortress Commander's Station?) by telephone and telegraph. Janson (67), when describing the system of conveying information, mentions the co-operation of the whole coastguard organisation. According to this writer's ideas, some of the coast observation stations are equipped with searchlights and captive balloons, and provided with large enough detachments to enable them to repulse any hostile attempts at effecting landings for special purposes from individual boats. These stations are connected with central stations inland for collecting news, the latter being also the headquarters of officers commanding certain areas, so that the necessary measures for protection can be at once taken on the receipt of news calling for such steps.

P.—METHODS OF CONSTRUCTION ON THE LAND FRONTS.

According to (12) coast fortifications can, on their sea fronts, be made impregnable to attack by hostile ships, and it is therefore from the land side that serious attacks are to be expected. The requisite steps for repelling the latter must therefore be prepared for beforehand. The paper then proceeds to deal with these steps in detail. According to Buinitzki (84), the artillery for resisting attacks from the land side is generally limited to light guns for close-range fighting; but they would have to be supplemented by guns of greater power, if the enemy undertook operations from the land on a wide front. The author then proceeds to deal with the fortifications of the land front.

Leithner (3) would make those works which are liable to attack both from the sea and from the land capable of resisting the heavy guns of the hostile ships and also a deliberately planned bombardment from the land side. He proposes the use of armoured forts for this purpose.

Stavenhagen (15) says that the land defences of coast fortifications partake of the character of a girdle fortress in cases where they are liable to attack by large forces.

The statements quoted in Part II. are generally applicable to the subject of the arrangement and construction of land fronts.

R.—THE GENERAL ARRANGEMENT OF FORTIFIED PLACES ON THE COAST.

Leithner (3) distinguishes between "Fortified Naval Harbours" (befestigten Kriegshafen) or Places of Accommodation for the Fleet (Flottenlagern), and "Fortified Points on the Coast" (befestigten

(84) "Über den Bau von Küstenbefestigungen": *Russ. Ing. J.*, 1899. Extract in *Mitt. A.-und G.*, 1900, page 901.

Küstenpunkten). The former would protect the naval depôts, dockyards, etc. and provide refuges for the fleet or parts of it, so as to afford it the opportunity of assuming the offensive. They would, as a rule, be provided with a number of more or less powerful batteries on the side facing the sea, whilst their land fronts would be arranged on similar lines to those of girdle fortresses. They would also have booms or obstacles in the water, commanded by artillery. Whether the coast works were proof against assault (sturmfrei) and constructed with closed gorges would depend upon the chance of attempts being made to storm them. According to Leithner such closed gorges, combined with a high degree of safety from assault, would be found in the case of "Fortified Points" intended to block entrances to canals and generally in those serving to protect coal depôts and commercial harbours. Leithner describes coast batteries and coast forts as the "Elements of Coast Fortification," and gives a number of illustrations. He points out, however, that the line of demarcation between these two classes of works is not very well defined.

Henning (16) often bases his observations on works which have actually been constructed. He dwells upon the necessity of arranging for protection from the rear in coast works, saying that all such works with very few exceptions could be taken by hostile attacks upon their gorges.

Brialmont (30) gives various examples of the disposition of coast fortifications. For the protection of bays and river mouths works are established on the coast itself, on islands, or in the sea, whilst it is also proposed to form barriers of self-acting mines flanked by torpedo batteries situated under water. The "active" defence by means of torpedo boats or gunboats is also taken into consideration. Brialmont frequently refers to existing works of coast defence and gives types of the forts and batteries proposed by him. Dealing with various English coast defences, he insists on the need of having an enceinte to protect the town and its valuable naval establishments.

Stavenhagen (15) considers that the distance between two naval harbours should not, if possible, exceed 400 sea miles, this being the distance which can be covered in 24 hours at a speed of 16½ knots. He distinguishes between the sea and land fronts of a coast fortress. The former consists of coast batteries, individual sea forts, batteries for close-range fighting and torpedo batteries, and of points of support for infantry, field artillery, and light Q.F. guns. The harbour blocking arrangements should, according to him, consist of minefields (one or more lines of mines) protected by gun batteries, torpedo batteries, and a fixed or floating boom (Barrikade). For the passive defence of the sea front searchlights for observation and communication purposes are required; and for the mobile defence coast flotillas, torpedo boats, and submarines. The part played by rockets (Leuchtfeuer) and beacons (Seezeichen) in coast defence is also dealt with. The fortifications on the land side would conform to the ordinary rules for land fortresses. Here as elsewhere Stavenhagen refers to the necessity of having a competent fortress staff. In (76) he deals with the arrangement of naval dockyards and fortified points.

Mielichhofer (5) and Schroeter (73) include sketches of coast fortifications in their books.

S.—THE APPLICATION OF PROVISIONAL AND FIELD WORKS.

As coast defences have to reckon with the possibility of having to sustain an attack immediately after, or simultaneously with, the commencement of hostilities, it is as a rule essential that they should be in the most complete state of readiness in peace time. In cases where special circumstances may render it necessary to supplement or supplant existing permanent works by others of a provisional or "field" nature, the methods described in the books mentioned in Part III. would generally apply. It would also be advisable to study the dispositions made during the War of Secession for the defence of coasts and rivers. Henning (16) deals briefly with the application of provisional and field fortification to coast defence.

T.—COAST FORTIFICATIONS IN VARIOUS COUNTRIES.

(*a*). GENERAL.

Besides the writings mentioned in Part I., C (*a*), we may refer the reader to the *Marine Rundschau*, *Mitteilungen über Seewesens*, *Nauticus*, and (4), (16), and (72) of this Part.

(*b*). GERMANY.

As the present subject is rather less familiar to officers of the army, it will be as well to call attention to some of the literature dealing with the German coasts. Stavenhagen (15) and Henning (16) have written about them. In (85) we are given a description of the nature of the coast bordering on the Bay of Kiel. The article (86) describes, among other things, the completion of the wireless telephony stations on the coasts of Germany.

The papers (87) and (88) are instructive, as is also (89), which

(85) "Zu der Küstenkriegführung vor Kiel": *Überall*, 1903–4.
(86) "Ausrüstung der Nordseeküste mit Funkspruchstationen": *Internat. Rev.*, 1905.
(87) "Die Küstenverteidigung an der Ostsee"; *ibid.*, 1904.
(88) "La Protection des Côtes Allemandes": *ibid.*, 1902, Suppl. 44.
(89) "Die Pforten der Ostsee": *Schweiz. mil. Zeit.*, 1905.

deals with the entrances into the sea in question and with the importance of the Kaiser Wilhelm Canal and of Copenhagen. The book (90), by Kardinal von Widdern, contains observations upon the strategical importance of the Frisian Islands and of the Wattenmeer (Zuider Zee) in a future war. Finally may be mentioned (91).

(*c*). ENGLAND.

The fortresses of Great Britain and Ireland are all coast defences. In (92) they are enumerated and classified as either fortresses or defended ports.

May (18) makes a most comprehensive study of the means of defence of the British Empire. The foundation of the latter is sea power, on which depends the commerce, the connection with the Colonies, and the retention of the latter beneath the supremacy of the Motherland. The first aim of English policy is therefore the retention of the command of the sea, which can only be effected by the possession of a powerful fleet. A great part of the Colonial Empire is certainly open to attack on the land, and even the Motherland has to take into account the possibility of a hostile invasion. Hence an army has to be maintained. The fleet, however, holds the foremost place, and the fortifications at home and abroad are for the benefit of the fleet. The fortresses, defended ports, and coaling stations outside the Home Country are enumerated and shown on a map, their objects and garrisons being briefly referred to. Maps are also used to illustrate the English lines of cable and the main English trade routes. In this connection reference is made to the construction of the Panama Canal, and the author also deals with the use of wireless telegraphy, besides referring to the contemplated "Cape to Cairo" railway.

An insight into the military organization of England is to be obtained by a study of this book, which goes but little into matters of detail. The same may be said of the work by Clarke (17).

The article (93) treats of the contents of (17).

(94) deals briefly with the British fortresses in and out of Europe. Bases for the fleet are also considered in (95).

(90) *Küstenschütz und Unternehmungen gegen denselben an der schleswig-holsteinisch-jutischen Küste im Feldzuge, 1864.* Berlin, 1906.
(91) Moltke's "Ansichten über feindliche Landungen an den deutschen Küsten": *Vierteljahreshefte für Truppenführung und Heereskunde*, 1906, Vol. 1.
(92) "Grossbritannien; Klassifikation der Befestigungen und deren Aufteilung auf die Korpskommandanten": *Mitt. A.-und G.*, 1905.
(93) "Die kriegerischen Machtmittel des britischen Reiches": *Überall*, 1903–04.
(94) "Stützpunkte der englischen Weltherrschaft": *N.M.B.*, 1905.
(95) "England und die Seeherrschaft im Mittelmeer": *Mar. Rund.*, 1904.

A book by Lewis (96) deals with the larger natures of fortifications, including both those intended to resist attacks from the sea and those constituting land fronts. It discusses almost all the details of fortification, the natures of guns to be used and the positions in which they should be placed, arrangements for ammunition supply, etc.

In connection with the latter work may be mentioned (97), which calls for the introduction of modern improvements.

The following articles are worthy of note, as dealing with the defence of the coasts of England:—(98), (99), (100), (101), (102), and (103).

Individual English fortresses and naval ports are dealt with by Stavenhagen in (104) and (105), and also in (106) and (107).

Interesting in connection with the defence of the English land frontiers are (102), (108), (109), and (110).

(*d*). FRANCE.

Patiens, in (111), describes the coasts of France, Corsica, Algiers, and Tunis. He says that Brest and Toulon, the two largest French naval ports, are secured against the possibility of being attacked with success, but he has much to find fault with in the cases of Cherbourg, Lorient, and Rochefort. The greatest possible importance should be attached to the protection of commercial harbours. For purposes of defence the whole French coast is divided into "Secteurs"; and the forces, both naval and military, entrusted with the defence of each "Secteur" are placed under the orders of the Commandant of that

(96) *Permanent Fortification for English Engineers.* Chatham, 1890.
(97) "Are our Ideas on Permanent Fortification Up-to-Date?": *R.E.J.*, 1906.
(98) "Die Denkschrift des ersten Lords der englischen Admiralität vom 6. 12. 04": *Mar. Rund.*, 1905.
(99) "Die neue Gliederung des Heeres und zugleich neue militärische Landeseinteilung in England": *M. W.*, 1905.
(100) "Englische Küstenbefestigungen," by Kurchhoff: *K.Z.*, 1902.
(101) "L'Invasion en Angleterre": *Revue Maritime*, 1903.
(102) "The Frontiers of the British Empire": *R.E.J.*, 1906.
(103) "The Possibility of our Fleets and Harbours being Surprised": *Jour. R.U.S.I.*, 1905.
(104) "Die englischen Kriegshäfen Plymouth und Portsmouth": *Mitt. A.-und G.*, 1904.
(105) "Der Kriegshafen Portland": *Danzer's Armee-Zeitung*, 1904.
(106) "Gibraltar": *M. W.*, 1903.
(107) "Concrete Work and Plant at Dover Harbour": *Beton und Eisen*, 1906.
(108) "Russland in Zentralasien und die englische Politik zur Gewannung der Grenzgebiete Indiens": *Mar. Rund.*, 1905.
(109) "The South of England as a Theatre of War": *Jour. R.U.S.I.*, 1904.
(110) "Der Kaukasus als Operations-basis, insonderheit gegen Indien": *N.M.B.*, 1905.
(111) *La Défense Nationale et la Défense des Côtes.* Paris and Nancy, 1894.

"Secteur." The defence arrangements in Corsica and Algiers-Tunis, the garrisons of the different "Secteurs," and the allotment of torpedo-boats to the latter, are, in part, dealt with in great detail.

A paper by Toudouze (112) gives no details, but is interesting in view of the historical retrospect which it contains, and of the proposals given for the reorganization of the coast defence of France.

The French coasts and the arrangements for their defence are very thoroughly considered by Stavenhagen in (113). He mentions that the coast defence of European France is divided into 5 "Arrondissements" which he enumerates, giving their limits and organization for purposes of command. In (114) the strength of France in submarines is referred to in discussing the new organization of the coast defence of Algiers. (115), in connection with the undertakings of the American fleet at Santiago de Cuba, refers to the opinions of a number of well-known authorities upon the subject of coast defence, and says that the warships of France are provided with the means of destroying lines of railway.

(*e*). ITALY.

In addition to the works mentioned in Parts I. and II. we may here call attention to the articles (116), which also speaks of the naval bases on the Italian coast, and (117).

(*f*). AUSTRIA-HUNGARY.

See Part I.

The following may also be mentioned :—(118), containing observations upon the existing coast defences and proposals for the construction of new ones, and (119), which is only a brief note upon the subject.

(*g*). RUSSIA.

The individual fortresses of Russia are dealt with in Parts I. and II.

The ideas prevailing in Russia on the subject of coast defences are thoroughly discussed in (120), in which a list of the accessible sources of information on the subject of coast fortifications is also given. We will also mention (121), by Buinitzki.

(112) *La Marine et la Défense des Côtes.* Paris, 1900.
(113) *Frankreich's Küstenverteidigung.* Berlin, 1902.
(114) "Unterseeboote in Deutschland und Frankreich": *N.M.B.*, 1905.
(115) *Navires de Guerre et Batteries de Côte.* Paris and Nancy, 1899.
(116) "Italiens Bedeutung als Seemacht im Mittelmeere": *Überall*, 1904–05.
(117) "Die Befestigungen Siziliens": *Mitt. A.-und G.*, 1905.
(118) "Unsere Kriegshäfen": *Danzer's Armee-Zeitung*, 1904.
(119) "Befestigung von Cattaro": *M.W.*, 1905, p. 2228.
(120) "Russische Anschauungen über Küsten- Behelfs- und Feldbefestigung nach der neuesten russischen Literatur": *Mitt. des I.-K.*, No. 41. Berlin, 1906.
(121) "Improvisierte Küstenverteidigung und ihre artilleristischen und technischen Hilfsmittel": *Russ. Ing. J.*, 1905.

(*h*). SCANDINAVIA, DENMARK, THE NETHERLANDS, BELGIUM, AND THE PYRENEAN PENINSULA.

See the works referred to in Parts I. and II. and also (122) and (123).

(*i*). TURKEY.

The fortifications of Constantinople and the Bosphorus are dealt with by Brialmont (30) and also in (124) and (125).

(*k*). THE UNITED STATES.

As in the case of England, the coast defences of the United States occupy the principal places among the land fortifications of the country. They are well described, with the aid of small sketches, by Kurchhoff in (126). In order to comprehend the existing arrangements, it is important to read (127) by Abbot.

The article (128) treats of the projectiles in use in the coast artillery of the United States. They are generally classified as A.P. shot and A.P. shells for use with guns, and D.P. shells and Torpedo shells for mortars.

The first two natures are intended to penetrate armour, the D.P. shells are for use against decks, the Torpedo shells are ordinary common shells. The paper describes the construction of the projectiles, as well as some of their more important parts. The material in the way of guns is dealt with in (129).

The necessity of having fortifications on the land side of coast fortresses is dwelt upon in the article (130), the arguments being based upon the War in the Far East and upon the double task which falls to coast fortifications of defending themselves against hostile ships and also against attacks from the land side.

Finally we may mention (131), which briefly discusses the defences contemplated and those already completed, and (132), an extract from the Report of the National Defence Commission which sat in the early part of 1906.

(122) "Die norwegischen Grenzfestungen": *Überall*, 1904–05.
(123) "Die Befestigungen von Lissabon": *M.W.*, 1905.
(124) "Der Weg nach Konstantinopel": *Streffleur*, 1902.
(125) "Die Verteidigungsfähigkeit des Bosporus und seine Befestigungen": *Schweiz. mil. Zeit.*, 1905.
(126) "Die Küstenbefestigungen der Vereinigten Staaten": *K.Z.*, 1905.
(127) *Defence of the Sea-Coast of the United States.* New York, 1888.
(128) "Coast Artillery Projectiles": *Jour. U.S. Arty.*, May and June, 1905.
(129) "Einiges über die Küstenbefestigungen der Vereinigten Staaten": *N.M.B.*, 1905.
(130) "Land Defence of Sea-Coast Fortifications." Extracts in *R.E.J.*, 1905.
(131) "Flotte und Küstenverteidigung der Vereinigten Staaten": *Überall*, 1904–05.
(132) "Coast Defence in the U.S. of America": *R.E.J.*, 1906.

The Panama Canal works and their importance are discussed in (133) and in (134) by Wachs.

(*l*). JAPAN.

Some information as to the naval ports of Japan is given in the *Mitt. A.-und G.*, 1904, p. 382.

U.—COAST WARFARE.

GENERAL.

No hard-and-fast rules can be laid down for coast warfare any more than for other natures of fighting. The method of subdivision of the subject adopted in the following pages is therefore only to be looked upon as a means of attaining clearness in dealing with the matter. A study of history, and a knowledge of the means of attack and defence, can alone enable one to get a proper grasp of the subject.

There are consequently comparatively few works devoted to coast warfare, and these are always based upon historical examples. On the other hand there are generally lessons to be learnt from the accounts of individual undertakings in coast warfare. We shall therefore pay particular attention to such accounts.

V.—BLOCKADE. BOMBARDMENT.

The purpose of a blockade, see (5), is to close a harbour completely from the side of the sea. The blockading fleet protects itself against any hostile action of the blockaded enemy by frequent changes of position and by establishing an advanced line of observation, consisting mostly of torpedo-boats, and against possible attacks on the part of a relieving Fleet, should one exist, by keeping a fleet of cruisers in observation towards the sea. The defence can be very dangerous for the attacker, especially with the submarine weapons now available.

In (135) Bloch sees in the lessons of the French and English naval manœuvres of 1888, 1893, and 1895 a confirmation of the view that it is impossible to shut up hostile ships altogether in a harbour. He discusses at length the modes of procedure for both sides in blockade operations. On the other hand the article (136) holds that good results may be expected from this method of warfare, especially in the case of harbours of great length and those which have a long

(133) "Über den Stand der Arbeiten am Panamakanal": *Prometheus*, 1905.
(134) "Le Canal de Panama au point de vue de la Stratégie Maritime": *Internat. Rev.*, 1906, Suppl. 82, taken from the *Kreuzzeitung*.
(135) *Der Seekrieg*. Vol. 3 of *Der Krieg*. Berlin, 1899.
(136) "Ein Rückblick auf die Seekriegsoperationen in Ostasien": *Nauticus*, 1905.

entrance channel, in spite of the unsuccessful blockade of Port Arthur. Foss (6) also considers a blockade quite feasible; but says that the ships of the attacker should be in every respect superior to those of the defender; if the latter has battleships, the blockader must also possess ships of that class. Foss then gives suggestions as to the mode of operation on either side. The Prize Essay of the English Lieutenant Dewar on Blockade in War, see (46), is very well worth studying.

The various forms of blockade are treated of in (137), whilst Dary, in (37), sees in the proper use of submarines a real aid to coast defence. These vessels should station themselves near the probable course of hostile ships, and sink them by means of torpedoes. It may here be remarked that, at the time of appearance of this book (1894), the question of submarines was far from being cleared up.

Mielichhofer (5) says that the main object of a bombardment is to destroy the naval outfit and organization of a harbour or port. The attacking fleet should therefore only engage the coast defences if the latter interfere with its main object, and should make the interior of the place its chief target. In order to be as little interfered with as possible by the coast artillery, the fleet should manœuvre outside the effective range of the guns of the former.

This implies keeping from 8 to 10 kilomètres (5 to 6½ miles) from the place itself; and must lead to the fire of the ships being directed more or less generally at the objective, for anything in the nature of precise firing will be out of the question, particularly if the ships have to keep moving in order to secure themselves as much as possible from the fire of the defending guns. The task of defence against bombardment falls mainly upon the coast artillery, but at the same time there is ample opportunity for any portion of the defender's fleet which may be shut in to participate in the defence.

Henning (16) produces a number of examples of bombardment from history to show that this method of attack has always led to the attainment of the object sought with the least loss in time, ammunition, and lives, provided that the place itself could be got at ("falls dem Platz beizukommen ist"). In opposition to this view Foss (6) holds that it will always take a long time and a large expenditure of ammunition to seriously damage a place. The same opinion is expressed in (115) and (127). According to the latter book the ships must keep in motion, having regard to the coast batteries. According to the investigations of Lieutenant Pappalardo of the Italian Artillery (138), the results to be obtained by fleets from bombardments of places on the coast are very small.

(137) "Die Grundlage für die Wahl der Blockadeform": *Mar. Rund.*, 1905.
(138) "Technische Mitteilungen": *Streffleur*, 1904, p. 212.

W.—THE ATTACK FROM THE SEA.

Mielichhofer (5) recognises a methodical form of procedure, divided into :—Reconnaissance and removal of the outer zones of obstacles; reconnaissance of the artillery defences; the attack by gun fire upon the works guarding the entrance to the harbour; reconnaissance and removal of the inner lines of obstacles; forcing the harbour entrance.

He deals with this method from the points of view of both the attacker and the defender in the case of a very carefully fortified place, going into the details of the subject. The various means of clearing away obstacles are discussed, the author remarking that this work will be very difficult even for a submarine, owing to the small field of view, to its disturbance by the surface motion of the water and by mist, and to refraction. The defender will use his guns and fleet to interfere with the reconnaissance and removal of obstacles. Torpedo-boats and submarines will operate against the smaller hostile ships, while mine-laying ships will make good any breaches in the mine-fields which the attacker may succeed in producing.

Speaking of the artillery fight, Mielichhofer says that the attacker is not concerned with obtaining a superiority of fire, but with the destruction of the object of his attack, and that this artillery fight is the most difficult and at the same time the most important phase of the attack. In this connection the measures to be taken both by the attacker and the defender are carefully dealt with by the author. The clearing away of the inner lines of obstacles should, if possible, be completed during the artillery fight, so that the endeavour to force the entrance may immediately follow upon the latter. Mielichhofer devotes some space to a thorough consideration of these two phases of the fight.

The book (139), by M.D.B.G., deals with the attack of coast batteries, bombardments, the forcing of harbour entrances, and landings. In connection with the artillery fight, it is said that the attacker will almost always know, before the war, all that is most important about the coast batteries at the point which most concerns his attack. Against these must his most effective fire be directed, although he must keep the other portions of the defence employed. The attacking fleet must keep moving during this artillery fight, its position being a very difficult one in face of the coast fortifications. In spite of all modern precautions a ship can be put out of action by a single effective hit, whilst a battery is very much aided by modern methods of construction, by the improvements in rangefinders and the consequently increased accuracy of fire, and by the co-operation of torpedo-boats, etc.

Foss (6) considers that the answer to the question whether ships should anchor or keep in motion whilst firing on coast works depends upon local conditions.

(139) *Des Opérations Maritimes contre les Côtes et des Débarquements.* Paris, 1893.

X.—THE ATTACK FROM THE LAND SIDE.

The article (140) says that the ships opposed to a fortified place on the coast are now more liable to close attacks than formerly; for the mines of to-day are no longer a source of danger to the torpedo-boats and submarines of the defence, and these vessels can therefore approach the hostile fleet more or less unobserved. It follows that the attacking fleet will have to keep farther out to sea, and leave the capture of the fortifications to forces disembarked for this purpose. History, moreover, shows that for hundreds of years past the main attack upon coast defences has, when successful, been made from the land side.

Mielichhofer (5) is also of opinion that in future an attempt to capture a naval port will as a rule only stand a chance of success when it is supported by action on land. The operations of the landed troops would be guided by the ordinary rules of land warfare.

Janson (67) says that a combined attack by the army and navy is the best way of guaranteeing success. In another place he discusses the measures to be taken to guard against landings; and says that, as far as preparations on the land itself are concerned, most depends upon the coast observation and signalling organization and upon the railway communications. He issues a warning against moving troops too precipitately. He considers that it is no great misfortune for the defender if he does not arrive upon the scene of action until the hostile landing has been completed, provided always that he is strong enough to defeat the enemy, who will be obliged to fight with the sea at his back. According to Foss (6) a fortified rallying position is a necessity for a landed army.

Grasset (72) makes a careful study of the method of action of landed troops and of the measures to be taken against them by the defenders. The landing of a complete army can be undertaken in order to capture, wholly or in part, a hostile country, to create a diversion, or finally with the object of obtaining possession of a great naval port or of a fortress. Expeditionary corps may be landed for the purpose of destroying weakly protected depôts or establishments of any kind, in order to levy contributions, or possibly to gain possession of some small piece of country.

Finally hostile ships may disembark landing parties, formed of their own crews, in order to operate against works of construction or lines of communication, or, under certain circumstances, to interfere with the process of mobilization. The author discusses at length the methods of action of attackers and defenders in each case.

In conclusion we may again call attention to the book referred to under (1) and its treatment of the subject of landings and measures of attack and defence to which they give rise.

(140) "Attacks upon Fortified Harbours": *Jour. U.S. Arty.*, May and June, 1905.

Y.—COAST WARFARE AND COAST DEFENCE IN MILITARY HISTORY.

The history of coast warfare is that of the fighting which has taken place on different coasts and round various coast fortresses. We can only here refer the reader to the Library Catalogues. A good guide to what to read is furnished by Grasset (72) in the Section entitled "Historique des Agressions tentées contre les Côtes depuis 1853." Historical examples applicable to the present subject are incidentally given by almost all the writers whose works have been referred to in this Part. The following may be mentioned :—(3), (5), (6), (16), (67) and (141).

A list of works dealing with the fighting round Port Arthur during the Russo-Japanese War of 1904–05 is given in Appendix I.

Most of the descriptions of fighting round places on the coast provide data as to the nature of the fortifications concerned, and thus form a groundwork for the study of these fortifications from the historical point of view.

(141) *Die geschichtliche Entwickelung des Seekrieges von der Zeit der Entdeckungen bis zur Gegenwart*, by Frhr. v. Maltzahn. Berlin, 1906.

PART V.

FORTRESS WARFARE.

OPERATIONS IN CONNECTION WITH FORTIFIED POSITIONS AND RIVERS.

A.—GENERAL.

According to (1) the principles of field warfare are now becoming more and more applicable to fortress warfare, although, in the case of the latter, the lengths of time taken by the successive phases will necessarily be much greater than in the former.

This line of thought admits of the further conclusion, that the mode of employing troops, and their equipment, in fortress warfare must be suited to the peculiarities of that class of fighting.

The works dealing with the construction and arrangement of modern fortresses have been mentioned in Part II. It now only remains, before considering the subjects mentioned in the heading of this Part, to call attention to those books which give us information as to the several arms of the service as used in fortress warfare and as to their equipment for this work.

B.—THE USE OF THE DIFFERENT ARMS.

INFANTRY.

In the introduction to (2) it is pointed out that now, as formerly and as in field warfare, the final decision in fortress fighting can only be attained by the infantry. Among other points this work discusses the attributes of rifles and machine guns and their application to fortress warfare. The conclusion is come to that the correct use of the modern rifle tends equally to shorten the attack on a fortress and to prolong the defence; and reference is made to the interesting points of difference between the methods of applying the use of the rifle to fortress and field warfare respectively.

In agreement with the above, Stavenhagen, in (3), says that infantry is the principal arm in fortress as in field warfare, irrespective of the importance of artillery. The work then goes on to consider

(1) *Krieg- und Heerführung*, by von der Goltz. Berlin, 1901.
(2) "Die Bedeutung und Verwendung des Gewehrfeuers im Festungskriege": *Mitt. des I.-K.*, No. 36. Berlin, 1904.
(3) *Grundriss des Festungskrieges*. Sondershausen, 1901.

the action of infantry in fighting of this kind, and, as we may add here in order to avoid repetition, the action of the other arms as well.

In (4) Schroeter, besides discussing the use of the rifle, reviews the question of the employment of the other weapons and of various technical appliances. This review is of interest in connection with almost all the other questions which we shall discuss later.

An essay by Leithner (5) enumerates the following demands which such fighting makes upon infantry:—The very extensive and important services of security and communication; the disproportionately large number of undertakings which have to be carried out at night; the frequent use of infantry as working parties; the exposure to harassing artillery fire for long periods, which is very trying to the morale. Leithner concludes that the allotment of inferior infantry to fortresses is unsound, and that from many points of view it is desirable that special units of fortress infantry should be formed.

The establishment of units of this kind is treated of in (6). Whether the training of siege infantry in field fortification, in destroying and crossing obstacles, and the consequent exclusion of pioneer regiments from fortress warfare, is sound will not be discussed here.

In (7) von Brunner deals with the work of infantry in the close attack, as well as with the rifle fire of the defence. In (8) Bernatzky includes some data as to the effect of rifle bullets.

Frobenius, in (9), gives some very instructive views upon the value of infantry in fortress warfare. He holds that the attacking infantry will not be able to cross the space in front of the works without cover, after the fortress artillery has been subdued, and that the lion's share of the work will fall to the infantry in the fighting round fortresses. In agreement with this, Müller, in (10), says:—However great the effect previously produced by the artillery may have been, the final decision will always have to be sought mainly from the infantry fight. To much the same effect is the remark made by Bauer, in (11), when he says that rifle fire has to-day become so effective that even in the fortress warfare of the future it will play a far more decisive part than has hitherto been supposed.

(4) *Die Festung in der heutigen Kriegführung*. Berlin, 1903 and 1905.
(5) "Die Infanterie in Festungskampfe": *Mitt. A.-und G.*, 1900.
(6) *Belagerungs-Infanterieregimenter und Belagerungsdivisionen im Frieden und auf dem Angriffsfelde*. Reviewed in *Mitt. A.-und G.*, 1903.
(7) *Der Festungskreig*. Vienna, 1899.
(8) *Kampf um vorbereitete Stellungen*. Berlin, 1904.
(9) "Das Schema im Festungswesen": *N.M.B.*, 1900.
(10) *Geschichte des Festungskrieges seit allgemeiner Einführung der Feuerwaffen bis zum Jahre 1892*. Berlin, 1892.
(11) "Die Infanterie im Festungskriege": *K.Z.*, 1903.

In (12) Medicus says that, in view of the powerful infantry defence which the defender will be able to make with the modern form of rifle, increased use of infantry in the attack will be necessary. We may finally refer here to (13), where the opinion is expressed that the infantry of a fortress should be equipped with automatic instead of magazine rifles, in view of the very few minutes during which the hostile storming columns will be exposed to their view.

For the close study of the weapons of all branches of the service we may refer the reader to subhead D of Part III.

C.—CAVALRY.

Frhr. v. Leithner says that the service of information of a fortress, apart from the use of spies, will be mainly the duty of the cavalry. That of the general reserve would be used for long distance reconnoitring patrols, and that of the sectional reserves for the reconnaissance of the country in the immediate front of the fortress. Smekal (14) expresses himself decidedly against the view that no cavalry units are required on the side of the attack besides the divisional cavalry. The tasks of cavalry in fortress warfare are thoroughly discussed by Frobenius (15), whose views are in agreement with those of Pelet-Narbonne in the course of a similarly named essay (15), in which the tasks assigned to this arm by Frobenius are further discussed.

D.—ARTILLERY.

(*a*). GENERAL.

In a work by Sauer (16), which appeared 21 years ago, but which is still very well worth studying, the fire effect of artillery and infantry is very thoroughly discussed. The same author, in (17), deals especially with the effect of rifle fire. In an essay (18) Deguise deals with the parts played by the artillery of the attack and of the defence respectively. According to this writer the artillery of the attack should destroy the guns of the defence and cover the pushing forward of the approaches. On the side of the defence the artillery should act against the first works undertaken by the enemy, carry

(12) "Beitrage zur Geschichte des Festungskrieges": *Jahrb. für A. und M.*, 1899, 1900, and 1905.
(13) "Das Selbstladergewehr im Festungskriege": *K.Z.*, 1905.
(14) *Der Angriff in Festungskriege.* Vienna, 1902.
(15) "Die Kavallerie im Festungskriege": *K.Z.*, 1901 and 1902.
(16) *Über Angriff und Verteidigung fester Plätze.* Berlin, 1885.
(17) "Gefechtslehre und Wurffeuer": *M.W.*, 1890, Beiheft, page 167.
(18) "Deux Questions relatives à la Tactique de la Guerre de Siège": *Recueil des Travaux Techniques des Officiers du Génie de l'Armée Belge*, 1900.

out the artillery fight, hinder the progress of the approaches, and secure the ground on which fortifications have been established.

In (19) Gerwien deals with the importance and tasks of the artillery, and its fire, both high angle and direct.

Finally we may refer to two works by Wiebe, (20) and (21), which are still instructive in spite of the time which has elapsed since their appearance. Brialmont's views regarding smokeless powder, as expressed in (22), are also of interest.

(*b*). FIELD ARTILLERY.

The work of field artillery in fortress warfare is dealt with by almost all the writers referred to under subhead D. We will only add a reference to (23) by Hübner.

(*c*). THE HEAVY ARTILLERY OF THE FIELD ARMY.

(This will be referred to, for the purpose of this Subhead, as the 'Heavy Artillery').

In (24) Sauer says that the attack must endeavour, as one of its principal objects, to hinder the placing in position of the fortress artillery. This latter process will, however, be facilitated by the considerable interval which must elapse from the time the attacker occupies his line of investment till he opens fire with his artillery, which he cannot do until the siege train has been brought up. The attacker should be so equipped with artillery that he will be able, as soon as he has completed his investment of the fortress, to oppose such guns of the defence as he may then expect to meet with guns at least approaching them in power, and thus hinder the further strengthening of the defender's lines. The same writer says, in (16), that the 'advanced guard' of an attack directed against a fortress must be able to make the investment fighting include the struggle for the outskirts of the place (Kampf ums Vorterrain), and that it will therefore require an equipment capable of dealing with exterior positions and advanced works. This leads the author to desire serviceable ordnance for high angle fire as well as good 'fighting guns' (Gefechtsgeschütze). The latter are available in the German field batteries, whilst the former would be supplied in the shape of 12-c.m. or 15-c.m. (4·8″ or 6″) mortars (howitzers). A brigade

(19) *Der Festungskrieg.* Berlin, 1898 and 1902.
(20) *Gedanken über den Artilleriekampf im Festungskriege.* Berlin, 1889.
(21) *Das rauchschwache Pulver und seine Bedeutung für den Festungskrieg.* Berlin, 1890.
(22) *La Défense des Etats et la Fortification à la fin du XIX. Siècle.* Brussels, 1895.
(23) "Die Feldartillerie im Festungskriege:" *K.Z.*, 1901.
(24) *Beiträge zur Taktik des Festungskrieges.* Berlin, 1882.

(Abteilung) of these howitzers, the horsing of which in peace is not absolutely necessary, should be attached as soon as possible—within 2 or 3 days—to the force directed against a fortress, and should form the 'advanced guard' of the siege army.

Whilst Sauer here allows the howitzer brigade to join the siege army after the lapse of several days, he later discusses the question whether it would not be sound to attach at least a half-brigade of howitzers with a supply of ammunition to those army corps which are intended for the operations against 'positions.'

Meanwhile the larger armies of Europe, as well as that of Japan, have provided heavy artillery for the field army or, in some cases, arranged for its provision on the outbreak of war.

A book by Bleyhoeffer (25) contains a very thorough study of this subject. It describes the doings of heavy artillery in the wars of recent years, and devotes attention to the tactics of foot artillery. The development of heavy artillery, the effect of its guns, its organisation in Germany and in other countries, the details of its work in action, and its employment under all kinds of circumstances in war, are thoroughly dealt with. This book, in answering (26), expresses the opinion that 'no infantry in the world will have the nerve to stand the fire of a field howitzer battery which has found the range, even if only a few hits are obtained on overhead cover of a field nature.' The best way of forming an opinion as to the correctness of this view is to study the histories of campaigns. Of the latter works we may here call attention to (27).

The essay (28), taken from the *Militär Zeitung*, says that the preparations on the part of the Germans in 1870 for fortress operations were very inadequate. It considers that the deficiencies which came to light in this connection postponed the termination of the campaign for several months; and that the want of proper equipment led to the Germans bombarding fortresses with field guns, or with French guns to the use of which the German gunners were strangers. Examples taken from the War of Secession and the Russo-Turkish War, among others, are quoted in order to show how important heavy guns have often been to a field army. The paper in question comes to the conclusion that heavy guns should accompany troops in field operations as well as in fortress warfare.

In (29) Frobenius refers to these horsed batteries as 'The advanced

(25) *Die schwere Artillerie des Feldheeres.* Berlin, 1905.
(26) *Wider die Feldhaubitze*, by Alten. Berlin, 1903.
(27) "Port Arthur: Ein Rückblick," by von der Goltz: *Deutsche Revue*, 1905.
(28) "L'importance de la Grosse Artillerie de l'Armée de Campagne au point de vue des Guerres de Campagne et de Forteresse:" *Internat. Rev.*, 1903, Suppl. 55.
(29) "Der Festungsangriff:" *Jahrb. für A. und M.*, 1898.

guard of the heavy siege train.' In connection with the attack on advanced positions he mentions Gerwien, who also deals with the heavy artillery.

Deguise (18) sees the principal value of the heavy artillery of the field army in fortress warfare in the power which their presence confers upon the attacker of carrying on his attack without a break. We see this view again expressed in (30) by the same author.

Smekal (14) concerns himself with the question of the best organisation for the heavy artillery of the field army, and, in the course of his studies, discusses with great thoroughness the method of employing this nature of artillery. Hoppenstedt, in (31), also devotes careful attention to ordnance for high angle fire and to the 10-c.m. (4") gun.

In (32) Schwarte lays himselt out to describe the fighting in connection with a large 'detached fort' fortress on the Elbe—Wittenberg—, and undertakings against a river line and against a detached fort in the same connection.

Volumes 1 and 2, which have appeared so far, deal, among other points, with the organisation of the heavy artillery of the field army and its employment in the attack of a detached fort, including the advance and the arrangements for the supply of ammunition.

See also the article (33).

(*d*). SIEGE AND FORTRESS ARTILLERY.

Stavenhagen (3) thinks that the attacker does not, as a rule, require to have a larger number of guns than the defender. He says, however, that *on the front attacked* the attacker should have about 1½ times as many guns available as the defender has on that front. He gives some general figures regarding the strength of a siege train, and discusses its organisation. For the defence of a fortress, Stavenhagen recommends a first artillery position, horsed batteries as a mobile reserve and to meet eventualities, and finally the reserve of heavy guns. In this connection we are told what duties the artillery of a fortress has to fulfil. It should form the means of protecting, by gun fire, the whole front against hostile undertakings on a large scale; it should afford the defender the means of engaging the enemy with the greatest possible superiority in heavy guns; and finally it should provide guns available for surprise action, for active operations in the country round the place

(30) *Attaque et Défense des Forteresses.* Brussels, 1898.
(31) *Der Kampf um befestigte Stellungen in Geschichte, Lehre und Beispiel.* Berlin, 1905.
(32) *Festungskrieg.* Berlin, 1905 and 1906.
(33) "Les plus Récents Principles de Combat de l'Artillerie Lourde d'Armée": *Internat. Rev.*, 1906, Suppl. 84, taken from the *Berlin Militär Zeitung.*

itself, and for occupying advanced positions. These principles for the allotment of the artillery of a fortress are met with in almost all the writings dealing with the subject, although the terms of description may vary.

Macalik and Langer, in (34), speak of a 'covering armament'—*i.e.* the guns which are intended to prevent the place being 'rushed' or overwhelmed by force of numbers before the defence is thoroughly organised—and of a reserve of guns, divided into mobile guns and heavy guns. The authors, in 4 numbers, deal with the question of the arming of a large fortress and the fighting in connection with such a place. The artillery siege park is discussed at length; and information given as to the number of trains required to carry it, the amount of road transport which would, under certain circumstances, be required for the ammunition, and the works necessary in connection with unloading stations, parks, and the laying of the requisite lines of rail. As a general rule each infantry division of the attack would be allotted one section of the siege artillery park, consisting of 64 guns. The book in question also treats of the heavy artillery with the field army, which it refers to as mobile battery groups.

In (35) Zell discusses the organisation of fortress artillery, the tasks which fall to the lot of the various fractions of it, and the most suitable calibres for the different purposes.

Smekal (14) deals with the organisation of the siege artillery park. He wishes to divide the heavy artillery into that for divisions and that for corps, each part to consist of 3 brigades (batterie-divisionen) of three 4-gun batteries. The heavy divisional artillery would have 36 pieces of ordnance for high angle fire, 15-c.m. (6″) howitzers and 21-c.m. (8·4″) mortars; the heavy corps artillery 36 flat trajectory guns of 12 and 15 c.ms. (4·8″ and 6″). For the supply of ammunition special parks would be formed and the necessary railway material allotted to them.

Rehm, in (36), says that to each siege group there should be allotted a section of the siege artillery park, consisting of twenty heavy mortars, 15-c.m. (6″) howitzers, and 12-c.m. (4·8″) guns, and a reserve section of twenty 15-c.m. howitzers and twenty 12-c.m. guns.

Gerwien (19) deals in detail with the armament of a fortress and the plan of arrangement for its guns, and also with the siege train and siege park.

Deguise (30) discusses artillery in the attack and defence of fortresses, the different natures of guns, their detachments, and their ammunition supply. He refers to the use of flanking fire for the

(34) *Der Kampf um Gürtelfestungen.* Vienna, 1901 to 1904.
(35) "Zur Frage der Armierung moderner Landfestungen im Manöverterrain": *Schweiz. Zeit. für A. und G.*, 1906.
(36) *Prinzipien des Festungsangriffes.* Vienna and Leipzig, 1898.

defence of the intervals and the employment of existing and specially constructed railways of various gauges.

To railway lines of this kind Tilschkert, in (37), attaches great importance. He argues that heavy guns tied to one position must constantly present a more or less favourable target to the enemy; whilst, as they will only fire about 60 rounds a day when firing deliberately, they really only need to leave their cover daily for about an hour in all. By extending the use of railway lines he thinks that it will be possible to let guns fire from various positions, and to keep them out of sight except when actually firing.

Brunner (7), when discussing artillery in the attack, refers to the organisation of the artillery siege park; and, when talking of the armament of a fortress, divides this into the artillery for resisting a 'coup-de-main,' that for use against an attempt to capture the place by sheer weight of numbers, and that destined to defend the fortress against regular siege operations.

Captain Angelis of the Italian army, in (38), comes to the conclusion that the 15-c.m. (6") gun can be used effectively from mountain fortifications against any target which howitzers or mortars could reach, provided that the charges are correctly adjusted. Hanika, in (39), advocates the equipment of fortresses with light field howitzers, holding that they will be of value in the preliminary fighting in the outskirts of the place, in the interval of time which must elapse before the siege artillery opens fire, in the decisive stage of the struggle, and in the close fighting.

E.—ENGINEERS. ENGINEER SIEGE PARK.

See also Part III.

In (40) Boguslawski arrives at the conclusion that artillery fire alone is insufficient to produce the fall of a properly defended place, and that one must use all available means to bring about the desired result.

Frobenius (29) says that in fortress, as in other fighting, artillery fire can only pave the way and shake the hold of the defence. The main task, the coming to grips with the defenders, must remain with the infantry. The guns should render this close approach possible and should support it; but the actual method of carrying it out must

(37) "Le combat d'artillerie sur la voie ferrée dans la guerre de forteresse de l'avenir. Le changement de position rapide des pièces lourdes": *Internat. Rev.*, 1905, Suppl. 77, taken from the *Militär Zeitung*.

(38) "Über die Verwendung von Geschützen mittleren Kalibers in Gebirgsbefestigungen": *Riv. A. e G.*, 1902. Extract in *Mitt. A.-und G.*, 1904.

(39) "Die Feldhaubitze im Kampfe um Festungen": *N.M.B.*, 1905.

(40) "Saragosse, Sebastopol, Paris, and Port Arthur": *Internat. Rev.*, 1905, Suppl. 72, taken from *Die tägliche Rundschau*.

rest with the infantry and the engineers, and it is they who have to carry out the necessary works.

The details of the part taken by the engineers are described by Scharr in (41). He deals with the fighting connected with a detached barrier fort, a barrier section, and a girdle fortress. In all the phases of such fighting, both in attack and in defence, there will be work for the engineers. Their duties embrace the destruction and repair of communications, the construction of simple field cover, the preparation of intermediate positions, and the work in connection with the fighting round the latter and at the enceinte itself.

Brunner (7) deals with the engineer siege train; and says that the engineer equipment of a fortress, given in his book, includes all the preparations and works which it is incumbent upon the staff and troops of the engineers to undertake in order to place the fortress in a proper state of defence. He also treats of the construction of 'approaches.' The latter are also discussed by Gerwien (19), who gives the approximate composition of a siege train and its division into several depôts.

Stavenhagen (3), under the head of "Formation and Organisation of an Investing Army," says that horsed engineer trains, and, as soon as the formal investment of a strong place has been decided upon, engineer siege units, will often be attached to the field troops formed according to paragraphs 40 to 44 of the "Field Service Instructions" (F.O. 40 bis 44). These units are dealt with in detail, and the organisation of an engineer siege train as well as the work of the engineers in attack and defence are described. In a similar manner Deguise (30) treats of the work of the engineers in the fighting round large and thoroughly equipped fortresses, round places which do not come up to the most modern ideas, and round small fortresses.

Schwarte (32) deals with the allotment of engineers in defence and attack, their formation in regiments, the siege train, attacks by sapping, obstacles, and arrangements for illumination.

Smekal (14) throws light upon the composition of an engineer siege park at the time when he wrote, makes proposals for its organisation on other lines, and for the most suitable method of allotting engineers to an investing army. The work deals, among other things, with searchlight detachments.

F.—TRANSMISSION TROOPS. OBSERVATION AND COMMUNICATION.

See also Part III.

Schwarte (32) mentions, among the requirements for an attack upon Fort Gollmer-Berg, a balloon section as well as the necessary telegraph units. He also includes in his remarks the use of agents and local residents for the purpose of obtaining information, and of carrier pigeons and field telegraphs for conveying news.

(41) *Der Festungskrieg und die Pioniertruppe.* Berlin, 1905.

Macalik and Langer (34) allow, for the fortress of Königgrätz, 3 balloon sections, 1 fortress telegraph section, and 2 fortress signal sections, and, for the investing army, balloon and field railway sections. (3), (7), (15), (19), and (30) all go more or less deeply into the question of arrangements, in attack and defence, for observation and communication. We may also mention (42).

Shooting at balloons is dealt with in (43) by Rohne, and in (44), (45), and (46).

G.—OTHER ACCESSORIES.

ARMOURED VEHICLES. RIVER GUNBOATS. SHIELDS. EXPEDIENTS FOR ENHANCING THE VALUE OF THE RIFLE. SCREENS AND MEANS OF DECEIVING THE ENEMY.

Armoured railway trains, as well as a few armoured road vehicles, have excited considerable interest, especially since the South African War. The following are sources of information regarding these, although their use is not peculiar to fortress warfare.

Historical examples are given in (47) by Brunner. Urbanski, in (48), considers that such trains would have a wide sphere of usefulness, but only in fortress warfare, and perhaps on the lines of communication. The essay (49) deals especially with the construction and use of the trains employed in South Africa. Armoured automobiles are described in short notices in the journal (50) and also in (51) and (52).

River gunboats are dealt with in (53), (54), (55), (56) for Austria-Hungary, and (57) for Germany and England.

(42) "Sur le Rôle des Observatoires Militaires pendant le Siège de Paris, 1870–71": *Rev. du G.M.*, 1900.
(43) "Das Schiessen der Feldartillerie gegen Luftballons": *M.W.*, 1905.
(44) "Noch einmal das Schiessen gegen Luftballons": *ibid.*,
(45) "Betrifft Bekämpfung von Fesselballons durch Artilleriefeuer": *Schweiz. Zeit. für A. und G.*, 1903, p. 76.
(46) "Le combat de l'artillerie contre les ballons captifs": *Internat. Rev.*, 1906, Suppl. 85, taken from the *Vedette*.
(47) "Über die Verwendung von Eisenbahnzügen zu Gefechtszwecken, namentlich im Festungskriege": *Streffleur*, 1900.
(48) "Über die Verwendung von Panzerzügen im Feldkriege"; *Mitt. A.-und G.*, 1900.
(49) "Die britischen Panzerzüge in Südafrika": *Streffleur*, 1901.
(50) *Die Armée*, 1902–03, p. 95.
(51) "Das Panzerautomobil": *K.Z.*, 1906.
(52) "Das gepanzerte Kriegsautomobil": *M.W.*, 1906.
(53) "Die Donauflotille, ihre Bedeutung und eventuelle Entwickelung": *Danzer's Armee-Zeitung*, 1903.
(54) "Die neuen Monitore Bodrog und Temes unserer Donauflotille": *ibid.*, 1904.
(55) "Die neuen Flussmonitore der k. und k. Kriegsmarine Temes und Bodrog": *Mitt. Seewesens*, 1904.
(56) "Notizen über Flussmonitore": *M.W.*, 1904, p. 2309.
(57) "Neuere Flusskanonboote": *Mitt. Seewesens*, 1904.

According to the newspapers, various states have introduced shields for use, in some cases by the infantry in others by the sappers. It is hardly ever possible to learn whether news of this character is in agreement with the facts. We may, however, here call attention to the short article (58), which contains the description of a sapper's shield, said to have been introduced in Belgium; and to (59), which describes a shield that is to be fixed to the rifle. In (2), besides shields, parapet reflectors for rifle shooting, rifle rests, range-finders, and telescopic sights are dealt with.

The value of screens and 'make beliefs' is undeniable for fortress as well as field warfare. Some of the works already referred to mention such contrivances, and they are specially discussed in the paper (60).

H.—ARMING SCHEMES AND THE ARMING OF A FORTRESS FOR WAR.

According to (61) a fortress should only require the guns to be mounted in order to be ready for war. The preparations to be made in peace for this 'arming' of the works are laid down in the armament scheme.

Frobenius, in his comprehensive work (62), when discussing the investment of Belfort, remarks that these schemes are important and very laborious compilations, but that things after all invariably turn out differently to what one expects. He considers the armament scheme of value as showing clearly the object which it is desired to attain; but thinks that those who draw it up must be thorough masters of their work, and must be capable of appreciating the relative values of the different parts of the scheme. This can only be ensured by having a capable fortress staff. When talking of works of construction which have to be undertaken after war has begun, in connection with the investment of Paris, the author says that the enemy must be constantly kept in mind, as in the case of field forti-cations. The works to be undertaken during the arming of the fortress should be so designed that, as in the case of shelter trenches in the field, they can always, at any stage of construction, be made capable of defence at a moment's notice. Moreover they should

(58) "Soudi da Zappa": *Riv. A. e G.*, 1905.
(59) "Ein schussfester Schild": *K.Z.*, 1900, p. 319.
(60) "Die Zukunftskriege und Scheinanlagen grossen Stils": *Schweiz. mil. Zeit.*, 1895.
(61) *Leitfaden für den Unterricht in der Befestigungslehre, im Verkehrswesen und im Festungskrieg auf den Königlichen Kriegsschulen.* Berlin, 1906.
(62) *Kriegsgeschichtliche Beispiele des Festungskrieges aus dem deutsch französischen Kriege, 1870–71.* Berlin, 1899 to 1906.

not be designed on a very large scale. Frobenius would avoid employing the garrison in the work of arming the forts, etc.; not because he thinks that the soldier should be regarded as being above even the most arduous labour in the preparation of the fortress for war, but because he considers that the troops allotted to the garrison should, above all things, be trained to the new kind of tactical work which they will be called upon to carry out and which will always be more or less strange to them.

The book in question advocates the most careful preparations in peace time for the formation of corps of workmen in war, so that these could, on the outbreak of hostilities, at once be allotted to the fortresses and set to work on the task of completing them for war.

Stavenhagen (3) treats of the arming of a fortress and the arming scheme with great thoroughness. In connection with the latter he discusses the 'orders,' the plan of allotment for the garrison, the strength in guns and their distribution, the establishment of engineers for the defence of the place, the administrative and sanitary arrangements, the war conditions ensuing upon the receipt of the order to mobilize or to arm the place, and the regulation of the duties of the staff and troops.

(7), (19), and (30) treat of the process of arming in a similar manner, with special reference to the views prevailing in the respective countries with which they deal. Leithner, (63), deals very thoroughly with this question of the arming of a fortress. Schwarte (32) and Macalik and Langer (34) discuss the process of arming as applied to the fortifications of which they treat.

I.—THE PLAN OF ALLOTMENT OF THE GARRISON.

Some of the works referred to under subheads B to H deal with the composition and organisation of the garrison of a fortress and the provisions regarding this garrison contained in the arming scheme.

We shall here mention a few more works treating of this branch of the subject.

Frobenius (62) shows the advantages attendant upon having fortress troops already posted in time of peace. Such troops are not only generally trained for the work required of them, but can also be made acquainted with the particular positions which they will be called upon to defend, etc. They can also be taken for duty as working parties without the risk of their training being interfered with.

Permanent fortress troops of this kind—cavalry excepted—are

(63) *Die beständige Befestigung und der Festungskrieg*. Vol. 3. Vienna, 1899.

maintained in Russia. For their organisation and method of employment see (64).

The question of special fortress troops is also dealt with in (65).

K.—ADVANCED POSITIONS.

In (66) Kuchinka says that the much disputed question of the value of such forward positions has lately been brought into prominence by the fighting around Port Arthur. He refers to Schroeter (4) and Stavenhagen (3) as the German authorities on the subject. The former is of opinion that the strengthening, by field or provisional fortification, of so-called advanced positions (vorgeschobene Stellung) as a means of holding on to outlying ground is, in the case of a fortress which is ready for war, a measure likely to weaken the place. Such a course, provided that the fortress is constructed on sound principles, would only be justifiable if the troops available for the defence far exceeded in number those allotted to it by the original scheme. Stavenhagen thinks that such field positions should only be used under exceptional and urgent circumstances.

Such positions appear to be regarded in another light in France, Russia, and Italy. Rocchi in (67) expresses the view that the occupation of advanced positions constitutes the only correct way of carrying on an active defence, and quotes the instance of the siege of Belfort.

In speaking of the investment of this same fortress, Frobenius (62) says that Denfert wished, by establishing advanced positions, to force the enemy to use up a disproportionately large force in securing the country outside the place; but that any slavish imitation of this procedure is to be carefully avoided, as was shown by the evacuation of the advanced position in the fortress manœuvres near Paris in 1894. Besides this, Denfert took trouble to arrange that his advanced positions and the ground immediately in front of them were within effective range of the guns of the fortress, for they were placed, as a rule, not more than 1,200 mètres (1,300 yards) from the works.

Deguise (18), after discussing this question, comes to the conclusion that any such advanced positions must be altogether avoided, if, by their occupation, the defence of the main position would be

(64) *Dienst der Truppen bei Angriff und Verteidigung von Festungen.* Published by the author in 1900, only with reference to the fortress of Iwangorod. Appeared in two editions in 1902. Republished in the *Russkii Invalide* in 1904. See also *Mitt. A.-und G.*, 1901, 1904, and 1905.

(65) "Beitrage zum Festungskriege": *Schweiz. Zeit. für A. und G.*, 1905.

(66) "Über Vorfeldstellungen im Festungskriege": *Mitt. A.-und G.*, 1906.

(67) *Traccia per lo Studio della Fortificazione Permanente.* Turin, 1902. Reviewed in "Italienische Ansichten über die beständige Befestigung und den Festungskrieg": *Mitt. A.-und G.*, 1903.

in any way injuriously affected. He also says that one must be quite clear in one's mind, when undertaking any operations in the country lying outside the place, as to the number of troops which one is going to employ, and as to the right moment at which to retire. This same writer also gives some very thorough instructions as to the method of occupying advanced positions (30).

For details as to these undertakings see the books referred to in Part III.

L.—THE COMPOSITION OF AN ARMY FOR THE CONDUCT OF A SIEGE.

This composition of course depends entirely upon the task in front of the army, the situation of the fortress, and particularly its garrison and works. A general knowledge of the subject is to be obtained from (7), (14), (19), (30), and (63). A study of the service text-books and of military history will amplify the knowledge thus acquired.

Smekal (14) opposes the idea that, in fortress warfare, it should rest with the commander of the army of investment to inform the supreme authorities of the army of the means which, in his opinion, he will require for the fulfilment of his task. This course may lead the officer in question to make demands out of all proportion to the necessities of the case, and tends to have an unfavourable influence upon the energy of his operations if by any chance all the means for which he asks are not placed at his disposal.

M.—FORTRESS FIGHTING.

GENERAL.

According to Vauban's system of attack, which prevailed for nearly two centuries in fortress warfare, the first parallels, see (10), were constructed some 575 mètres (630 yards) from the place, and then the artillery opened with a careful and deliberate fire. By means of approaches and saps the attack went on until the glacis was crowned. Finally, after the breaching and counter batteries (mostly firing from the place where the crowning took place) had done sufficient damage, the breach was stormed, the ditch being crossed by descending into it and climbing up the other side, or by bridging, according to local conditions. The artillery attack, according to this system, endeavoured to obtain the mastery more by the careful distribution and location of the batteries than by bringing an overwhelming number of guns into action.

If, as Frobenius says (62), this regulation attack on Vauban's system met its death blow at the siege of Sebastopol, nevertheless the fortress fighting of the following decade, round Duppel and in the War of Secession, failed to produce a substitute.

In (68) Krebs says that the way in which the formal attack was carried out at Duppel no longer forms an example suitable for modern conditions.

In the year 1870 a Commission composed of artillery and engineer officers assembled in Berlin in order to evolve a scheme for the attack upon fortresses.

The labours of this Commission, to which Frobenius devotes some attention in (69), were interrupted by the Franco-German War. Some of the members were, however, attached to the force besieging Strassburg, and had the opportunity of applying principles which had been adopted at the meetings of the Commission.

The numerous examples of fighting round French fortresses during this war saw many different methods of attack adopted—investment with the object of reducing the place by hunger, the formal attack, attempts at 'rushing' the works, and bombardments by guns of all natures. Vauban's method had been given up and no other found to take its place (No. 8, Longwy, of 62).

In the eighties there appeared a number of writings by Sauer dealing with fortress warfare, namely those mentioned under (16), (17), and (24), and also (70). To the views expressed by this writer so much importance was attached by Rehm in (71), that he treated Sauer's method as a substitute for Vauban's method of attack. The latter contemplated the destruction of the long-range weapons of the defence for good and all; whilst Sauer dispensed with such a complete mastery over the defending guns, and concerned himself with silencing these only for certain spaces of time, when an attempt at storming was being made. In the course of his observations on the two methods, Rehm expresses the opinion that the tactics of fortress warfare should aim at avoiding the close attack altogether. He then sketches out a method which is intended to render this close attack unnecessary.

In (29) Frobenius deals with this last scheme, after he has spoken of the approach and deployment of the artillery in connection with the question—'Is the formal attack a purely artillery matter?'—and has discussed the close attack. In the same article it is said of v. Sauer that he caused a commotion in the whole military world by his work (70).

Medicus (12), after discussing the deep-seated change which has occurred in the principles of fortress warfare, comes to the conclusion

(68) *Kriegsgeschichtliche Beispiele der Feldbefestigung und des Festungskrieges.* Berlin, 1901.

(69) "Der moderne Festungskrieg und der Angriffsentwurf der preussischen Kommission von 1870": *Jahrb. für A. und M.*, 1900.

(70) *Der abgekürzte Angriff gegen feste Plätze und seine Abwehr.* Berlin, 1889.

(71) *Taktische Betrachtungen über den Festungsangriff und die permanente Fortifikation der Gegenwart.* Vienna and Leipzig, 1895.

that, as in field warfare, general tactical principles alone can be laid down, not definite rules.

In agreement with this opinion Frobenius (9) is against any hard-and-fast methods in fortress warfare. But at the same time he agrees with Brunner, introduction to (7) that a definite system is required for instruction in this subject, and sees no danger in having a prescribed system of this kind, for "the man who is unable to shake himself free from the standard method when necessary would be hopelessly lost if no such method existed."

Agreeing as we do with this view of the matter, we shall touch upon some suggested methods of attack. At the same time we need hardly say that any hard-and-fast adherence to these methods should be absolutely avoided.

N.—METHODS OF ATTACK.

Schroeter (4) says that the attacker should in each case ask himself the question—'How can I obtain possession of this fortress in the shortest time, with the greatest certainty, and with the greatest economy of strength?' The work proceeds to consider, in this connection, the possible ways of attaining the object sought.

These are :—

(*a*). REDUCTION BY HUNGER. INVESTMENT.

According to Schroeter, this method will lead to success, provided that the necessary strength in troops is available and that the general situation admits of the delay involved. Krebs (68), when speaking of the events round Metz in 1870, says that the surrender of the fortress was entirely caused by hunger and spade work; but that the presence, within the lines of investment, of the large French field army certainly hastened the end. The investment of Metz was most completely carried out.

Deguise (30) investigates the respective strengths of an investing army and the forces which are shut in.

Among other works, (3), (7), and (61) deal with investments, both when carried out in conjunction with other methods of attack, and when used alone with the object of reducing the place by hunger. They as a rule include, in their treatment of the subject, all the other methods (which we shall presently consider) of conducting operations in connection with fortresses, and, to avoid repetition, we shall not refer to them again.

(*b*). SURPRISE.

This method, see (4), presupposes a very inferior adversary; and could only be successful nowadays in the case of a neglected frontier fortress either immediately after the declaration of war, or by breaking the peace, or under extraordinarily favourable circumstances. A study of military history will show how seldom surprise attacks have succeeded, especially in the case of works which are constructed so as to be 'storm proof.'

(*c*). BOMBARDMENT.

According to (4) this method is generally very rapid and proportionately economical, but at the same time very uncertain.

Bombardment has often been objected to on humanitarian grounds. These views are dealt with by Wagner in (72), where he says that the formal attack upon the enceinte of a fortress costs many more lives and destroys much more property than a bombardment.

Frobenius (No. 7 of 62) endorses the views of Wagner and Brialmont as to the admissibility of bombardments. He himself comes to the conclusion that no considerations should prevent an army adopting this course, if by its means the fall of a fortress can be ensured. He then discusses the question of the extent to which this method can be looked upon as certain in these days.

In agreement with Frobenius as to the right to bombard, (73) says, in discussing the fighting round Paris in 1870–71, that the attacker is justified in making use of any method of attack which promises to hasten the fall of the fortress.

(*d*). THE FORMAL ATTACK.

According to Schroeter (4) this consists as a rule in penetrating the enemy's main defensive position on a broad front, whilst keeping a force in hand for the protection of each flank. The principal tasks for both the attack and the defence, in connection with this method, are discussed.

Smekal (14) dislikes any special name being given to a certain form of attack; for a name often has a magnetic force of attraction, and might prevent a commander who had adopted a standard method of attack from changing, should opportunity occur, to another which offered a chance of attaining the object sooner. Smekal will only recognise in every procedure, divested of all accessories, the attack. He discusses the various phases of the attack, and comes to some very interesting, although not universally accepted, conclusions. He considers that the investment of a modern fortress of medium size will be very exceptional, and only likely to be carried out by an army greatly superior in numbers to the defenders. He is also doubtful as to the soundness of this form of attack. His treatment of the subject, which carries us through all the phases up to the pursuit after the

(72) "Die Bombardementsfrage": *Jahrb. für A. und M.*, 1898.
(73) *Die Festung in den Kriegen Napoleons und der Neuzeit. Studien zur Kriegsgeschichte und Taktik.* Vol. 4. Berlin, 1905.

place has been stormed, puts the principles of fortress warfare before his readers in a form easy to be understood by the army at large. The book also shows how the tactical principles of field warfare apply to the attack upon a fortress.

Macalik and Langer (34) apply the formal attack to specific cases. Their methods have given rise to an interesting exchange of views upon the question of the position and employment of outposts on the side of the defence; this is dealt with in the paper (74).

Leithner (63) expresses interesting views as to the conduct of the defence against formal attack. The procedure in attack and in defence is briefly dealt with in (75).

Hanika, in (76), considers that a well equipped and defended fortress of modern construction must be overcome by successive stages; but that it will not be possible to storm a front of several kilomètres, and a suitable point of attack must be chosen and captured. The besieger should concentrate the fire of his heavy mortars upon a point of this kind.

Blanc, in (77), deals with the tactical procedure, the employment of artillery, infantry, etc.

There remains only to be mentioned, of the phases of the formal attack, the assault or storm.

Schwarte (32) discusses the organisation of storming parties and storming sections, their equipment with storming appliances, and the conduct of the attack and defence in connection with the assault. Storming is treated of in much the same way by Macalik and Langer (34).

Scharr (41) gives a proposal for the composition of storming parties with special reference to the work of the engineers in attack and defence. Leithner (63) dwells upon the necessity of the utmost alertness on the part of the defenders as the time when a storm is likely to be attempted draws near. He also touches upon the use of rapid fire, brought to bear on the ground in front of the works, and the illumination of the foreground.

Krebs (68), speaking of the capture of Kars by surprise in 1898, points out how the success of the Russians was partly due to the undetected approach of the columns which were about to storm the works.

In (78) Ludwig describes a number of undertakings of this class which have occurred in military history, and refers to the correspond-

(74) "Die Vorposten des Festungsverteidigers": *Streffleur*, 1903.
(75) *Taschenbuch für den Pionieroffizier*. Berlin, 1904.
(76) "Über das Niederkampfen moderner Werke auf der Hauptangriffsfront im Festungskriege": *K.Z.*, 1906.
(77) "Angriff auf ein modernes Fort": *ibid.*,
(78) "Der Sturm im Festungskriege": *Vierteljahrshefte für Truppenführung und Heereskunde*, 1905.

ing phase of an action in the field. He expresses the opinion that, as in field warfare, the troops must be given a considerable degree of latitude as to the manner in which they carry out an assault; for it is only the terrain, and not the tactical principle involved, which differs in the case of the storming of a fortress. (79) and (80) are two articles which deal with the views expressed by Ludwig.

(c). THE COUP DE MAIN. (*DER FLÜCHTIGE ANGRIFF*).

The attacker who adopts this method must, according to Schroeter (4), dispense with an absolute superiority in gun fire in the case of large fortresses, and must attempt to take the defender by surprise and compel him to split up his forces. A large number of the books already mentioned deal with this nature of attack, although often under other names. We may mention here (30), (32), (34), (41), and (70).

O.—OPERATIONS IN CONNECTION WITH BARRIER FORTS.

According to (73) it is unnecessary to leave large forces behind in order to effect the capture of these forts. When the artillery of the attack has once opened fire, that of the defence will be kept fully occupied; and, as the garrisons of such forts are not usually large, a comparatively small number of troops will be able to bring the attack to a successful conclusion.

Sandier, in (81), distinguishes between completely detached barrier forts and those which form part of a large barrier system. Operations in connection with both classes are dealt with. Bleyhoeffer (25) considers that the heavy artillery of the field army should be used against barrier forts. Schwarte (32) deals in detail with the fighting round the advanced and detached fort of Gollmer-berg. We may also mention (19), (30), (41), and also (82), in which Piarron de Mondesir combats the view which assigns little power of resistance to these works.

P.—OPERATIONS IN CONNECTION WITH "STRENGTHENED POSITIONS." (*VERSTÄRKTE STELLUNGEN*).

The definition of a 'strengthened position' is not very clear; its degree of strength is nowhere laid down. Gerwien (19) uses this term; Schroeter (4) distinguishes between 'extemporary fortification' and 'deliberate field fortification' (geplante Feldbefestigung); Hoppenstedt (31) speaks of fortified positions; Bleyhoeffer (25) of

(79) "Über Festungskriegfragen": *M.W.*, 1905.
(80) "Neues auf dem Gebiete des Festungskrieges": *Jahrb. für A. und M.*, 1905.
(81) *Organisation, Attaque, et Défense des Places.* Paris and Nancy, 1896.
(82) *Comment se Défend un Fort d'Arrêt.* Paris and Nancy, 1906. (B.I.K.).

fortified field positions. The ideas as to the preparation of such positions and the means to be employed vary as much as the terms used to describe them. The particular circumstances of each case must here, as in fortress operations, or even to a greater extent than in their case, determine the amount of work and armament required and the measures for defence and attack. There is not much literature dealing with this subject. Besides (30) we may call attention to (83) and to Bernatsky (8), who describes operations with regard to 'strengthened positions' very thoroughly, discussing their nature, the defence, the attack, use of artillery, etc.

R.—OPERATIONS IN CONNECTION WITH RIVERS.

In "Angriff und Verteidigung von Stromlinien," see (1), von der Goltz says that every stream of any importance is of value in the defence of a country. He also says that the initiative, and therewith a great advantage over the defender, rests with the attacker.

Balk, in (84), deals with the fighting in connection with various Italian and German rivers. Krebs (68), in the sections "Die Danewerke und die Befestigungen an der Schlei" and "Die dänischen Verteidigungseinrichtungen auf Alsen und der Übergang am 29 Juni, 1864," discusses this nature of fighting, showing what points should be particularly attended to.

The paper (85) deals with the measures adopted by the Austrians after their defeat at Königgrätz, in order to make strategical use of the Danube, and the counter steps taken by the Prussians.

Schwarte (32) treats of this subject on a large scale when he describes the course of imaginary operations in connection with the Elbe between Torgau and Magdeburg, the river line being defended by an army and by fortifications.

The article (86) deals with the conduct of war on the lines of these rivers in connection with the exercises in question.

S.—OPERATIONS IN CONNECTION WITH FORTRESSES, 'STRENGTHENED POSITIONS,' AND RIVERS IN FOREIGN ARMIES.

(*a*). GENERAL.

In addition to the works mentioned in subhead C, Part I., we may note (3) and (25).

(83) "Der Kampf um Stützpunkte": *Schweiz. mil. Zeit.*, 1906.
(84) "Napoleonische Anschauungen über Flussverteidigung": *Jahrb. für A. und M.*, 1901.
(85) "Die österreichische Donauverteidigung im Jahre 1866 als Beispiel einer indirekten Flussverteidigung": *M. W.*, 1905.
(86) "Die grössere Pionierübung am Rhein und Main," *1905*: *Mitt. des I.-K.*, No. 42. Berlin, 1906.

(*b*). BELGIUM.

Besides Deguise (30) and Brialmont, who in his various works repeatedly deals with fortress warfare, we may call attention to (87).

(*c*). ENGLAND AND THE UNITED STATES.

Fortifications in these countries are mostly connected with the question of coast defence. The books on the subject are quoted in Part II. We may also mention (88).

(*d*). FRANCE.

Of official works attention may be called to (89) and the supplementary (90). Both these books are reviewed by Rohne in (91).

See also (92), (93), (94), (95), (96), (97), (98), (99), (100), and finally (101).

(*e*). ITALY.

Besides (67) we may mention (102), by Spaccamela.

(87) *Attaque et Défense des Places*, by Libbrecht and Cabra. Brussels, 1895.

(88) "Über die schwere Artillerie des Feldheeres und die Belagerungsartillerie in Grossbritannien": *Mitt. A.-und G.*, 1906.

(89) *Instruction Generale du 4 Février, 1899, sur la Guerre de Siège*. Paris, 1899.

(90) *Instruction Provisoire sur le Service de l'Artillerie dans la Guerre de Siège*. Approuvée par le ministre de la guerre le 20 Octobre, 1904. Paris and Nancy. (B.I.K.).

(91) "Die französische Anleitung für Angriff und Verteidigung fester Plätze": *Jahrb. für A. und M.*, 1905.

(92) *Étude sur le Service des Troupes du Génie dans la Guerre de Campagne*, by Duval-Laguierce. Paris and Nancy, 1893.

(93) *Attaque des Places*, by Hennebert. Paris, 1896.

(94) *Fortification*, by H. Plessix. Paris, 1894.

(95) *Manuel Complet de Fortification*, by Legrand-Girarde. Paris and Nancy, 1900.

(96) "Essai sur l'emploi tactique de la fortification de campagne," by Legrand-Girarde: *Rev. du G.M.*, 1904.

(97) "De la Fortification de Campagne," by Dupommier: *ibid.*,

(98) *Étude sur la Fortification Permanente*, by Dupommier. Paris and Nancy, 1900.

(99) "Défense Offensive dans l'Attaque Décisive et Reconnaissance d'État-Major de la Position de Magny-Fouchard": *Rev. du G.M.*, 1904.

(100) "Les travaux de Fortification de Campagne et l'Armament Actuel": *ibid.*,

(101) *Enseignements Tactiques découlant de la Guerre Russo-Japonaise*, by Niessel. Paris, 1905.

(102) *Fortificazione Improvisata, Attacco e Difesa di Localita e di Posizioni Fortificate*. Rome, 1891.

(*f*). AUSTRIA-HUNGARY.

(103) also deals with the heavy artillery of the field armies of most other states. (104), by Ritter Malczewski v. Tasnawa, contains some references to the instructions of some other armies upon this subject.

(*g*). RUSSIA.

See :—(105) by Jocher, (106) by the same, (107) by Klokatschew, and (108). Finally we may call attention to a comprehensive work (109).

(*h*). SWITZERLAND.

(110) is a work undertaken, by direction of the authorities, by a Swiss general staff officer.

(*i*). JAPAN.

See (111) and (112).

T.—OPERATIONS IN CONNECTION WITH FORTRESSES, 'STRENGTHENED POSITIONS,' AND RIVERS IN MILITARY HISTORY.

For the study of individual instances of such operations we must refer the reader to the Library Catalogues.

Müller (10) deals with the events of fortress warfare, with sole regard to the state of fortification at that time. (113) deals very thoroughly with the subject, particularly from the artillery point of view.

(103) "Die Belagerungshaubitzdivisionen (schwere Artillerie des Feldheeres) in Österreich-Ungarn": *Streffleur*, 1905.

(104) *Die Schlachtfeldbefestigung nach den Erfahrungen des russisch-japanischen Krieges.* Vienna, 1905.

(105) *Festungskrieg oder Angriff und Verteidigung von Festungen.* St. Petersburg, 1891; new edition, 1898.

(106) "Die russischen Festungsmanöver bei Ust-Jzora im August, 1902": *Streffleur*, 1902.

(107) "Der förmliche Angriff auf eine zeitgemässe Landfestung": *Russ. Ing. J.*, 1902 and 1903.

(108) *Festungskrieg oder Angriff und Verteidigung von Festungen.* St. Petersburg, 1904.

(109) "Russische Anschauungen über Festungskrieg und ständige Befestigung nach der neuesten Russischen Literatur": *Mitt. des I.-K.*, No. 35. Berlin, 1904.

(110) *Grundsätze der Schlachtfeldbefestigung und des Kampfes um verschanzte Stellungen.* Berne, 1896.

(111) "Die japanische Felddienstordnung, Abschnitt:—Belagerung einer Festung": *M.W.*, 1904.

(112) "Japanische Bestimmungen für die Arbeiten der Infanterie und Pioniere beim Angriff auf befestigte Stellungen, Ingenieurangriff": *Mitt. A.-und G.*, 1906.

(113) *Die Tätigkeit der deutschen Festungsartillerie bei den Belagerungen, Beschiessungen und Einschliessungen in deutsch-französischen Kriege 1870–71.* Berlin, 1898, 1899, 1900, 1901, and 1904.

We have already called attention to (62) by Frobenius. At the end of each section of this work the author discusses with great care actual instances illustrating the subject dealt with. We may also note (114) by the same author.

Gundelach, in (115), sets himself the task of discovering why the French fortresses had so great an influence upon the operations. Krebs (68) quotes historical instances in connection with the various sections of the subject, *e.g.* Drawing up the plan of attack; construction of the covered artillery position; attack upon the enceinte, etc. Operations in connection with 'strengthened positions' are also illustrated by examples from history. In addition to (73) we may mention (116) by Wlaschutz. Finally attention may be called to (9), (12), (25), (31), and (93); and to (117) and (118).

(114) *Befestigte Stellungen im Lichte des Krieges 1898–99.* Berlin, 1900.
(115) *Festung und Feldarmee im Kriege 1870–71.* Berlin, 1902.
(116) "Bedeutung von Befestigungen in der Kriegsführung Napoleons": *Mitteilungen des k. und k. Kriegsarchivs.* Vienna, 1905.
(117) *Ingenieure und Pioniere im Feldzug, 1870–71. Belagerung von Strassburg*, by Pirscher. Berlin, 1905.
(118) "Versehen im Befehls und Nachrichtenwesen während des Feldzuges 1870–71": *M.W.*, 1906.

SUPPLEMENT.

PART I.

A.

Questions de Défense Nationale, by Langlois (1), and "General Langlois über moderne Befestigungen und den Festungsangriff" (2), give us the views of General Langlois as to the value of permanent fortifications.

C (*a*).

Militär-Lexikon, Berlin, 1901, by Frobenius, brought up to 1904. (A Supplement, dated November, 1906, has since appeared.—Transr.).

PART II.

B.

An essay, entitled "Über die Erwägungen, die zur Theorie der Panzerfronten geführt haben" (3), arrives at the conclusion that this theory is the only one which fulfils modern requirements.

PART III.

D.

Supplement No. 1 to *Berlin: Handbuch der Waffenlehre*, entitled "Die Neuerungen der Handfeuerwaffen und Maschinengewehre" (4), should be noted.

E.

The two papers, "Die Pioniere auf dem Schlachtfelde von Königgrätz" (5) and "Die Ausbildung der Pioniertruppe" (6), give useful information as to the employment of engineers. "Le Retranchement de l'Infanterie dans l'Attaque" (7) points out the disadvantages of entrenching in the attack, and, in connection with the latter, gives views as to the use of the spade.

F.

In "Die befestigte Feldstellung im Dienste der Operation" (8), Warnberg deals with the co-operation of the different arms, especially of the infantry and engineers, and with the necessity of arranging for the smooth working of the command machinery when organising a position in the field.

(1) Paris, 1906.
(2) *Mitt. A.-und G.*, 1906.
(3) *K.Z.*, 1906.
(4) Berlin, 1906.
(5) *Vierteljahrshefte für Truppenführung und Heereskunde*, 1906.
(6) *ibid.*,
(7) *Internat. Rev.*, 1906, Suppl. 84, taken from *Militär-Zeitung*.
(8) *M.W.*, 1906, Beiheft, p. 289.

G.

In a paper entitled "Dampfstrassenlokomotiven für Heeresdienst" (9), we are told of a steam plough specially designed for throwing up trenches.

H.

"Über Kavalleriepontons" (10) gives brief historical notes on the use, by cavalry, of means of effecting crossings over rivers. An example of such work is described in detail, and an account of the cavalry bridging equipment in the German and French armies is also added. "Der Bau einer Behelfsbrücke über den Main bei Kelsterbach und die Anlage eines Brückenkopfes daselbst im Verlauf der Pionierübung 1905" (11), founded on official sources of information, gives a detailed account of the undertakings in question. See also (86), mentioned in Part V.

We may also call attention to *Conversation sur les Passages de Cours d'Eau par les Troupes* (12), by Habert.

L.

Die Feldtelephonie der Gegenwart (13), by Ramdohr, deals with the use of the telephone with the staff and troops, and also goes into the technical part of the subject.

O (*g*).

Buinitzki: *Kurzer Lehrgang der theoretischen Feldbefestigung* (14).

PART IV.

A.

Nauticus contains several articles worth noting:—"Die Marinevorlage 1906 und die Fortentwickelung der deutschen Kriegsmarine"; "Der gegenwärtige Stand der Unterseebootsfrage"; "Artillerie und Panzer im ostasiatischen Kriege"; "Die Fortschritte der Funkentelegraphie, ihre wirtschaftliche und militärische Bedeutung."

Modernes Seekriegswesen (15) by Pluddeman is particularly intended for the information of Army officers. It deals with naval artillery, booms, searchlights, bombardments from the sea, transport and landings, blockades, etc.

H.

According to newspaper reports the Lloyd Steamer *Bremen* has recently succeeded in exchanging wireless messages on the "Telefunken" system with the station at Nauen, at a distance of 2,500 kilomètres (1,550 miles), when on the voyage to New York.

No views have as yet been published as to the effect which the Poulsen waves, which are much talked about, will have upon the military value of wireless telegraphy.

(9) *Schweiz. Zeit. für Art. und G.*, 1906.
(10) *Streffleur*, 1906.
(11) *K.Z.*, 1906.
(12) Chalons-sur-Marne, 1905.
(13) *K.Z.*, 1902, and Berlin, 1903.
(14) St. Petersburg, 1906.
(15) Berlin, 1902.

J.

"Über Seetransporte und Ausschiffungen" (16) deals briefly with the subject of this subhead, giving German authorities for the most part. See also "Peace Preparations for Oversea Expeditions" (17).

T (*c*).

"Gibraltar und Port Arthur" (18) gives information as to the fortifications of the former place.

PART V.

B.

"L'infanterie dans la guerre de Forteresse" (19) deals with operations round a Fort Fortress and round a Barrier Fort, dwelling particularly upon the work of the infantry in each case.

D (*a*).

A completely new edition of *Festungskrieg* by Gerwien, see (19), is expected in the autumn of this year.

D.

Festungskrieg by Schwarte, see (32) of Part V.; volume 3 is expected this winter, and volume 4 in the autumn of 1907.

F.

"Beobachtungsdienst in festen Platzen" (20) lays some stress upon the advisability of allotting captive balloons to fortresses.

H.

The eleventh number of (62), Part V., by Frobenius, dealing with the Siege of Belfort, has appeared. The concluding number is now to come.

We may also notice here:—"Festungskrieg in Theorie und Praxis" (21), by Schwenniger.

O.

By Hanika:—"Über den Angriff auf Grenzsperren" (22) and "Über die Verteidigung von Grenzsperren" (23).

R.

"Die Schwere Artillerie des Feldheeres bei Flussübergangen" (24).

(16) *Mitt. A.-und G.*, 1906.
(17) *Jour. R.U.S.I.*, 1906.
(18) *N.M.B.*, 1906.
(19) *Internat. Rev.*, 1906, Suppl. 89, taken from the *Militär-Zeitung*.
(20) *K.Z.*, 1906.
(21) *Jahrb. für A. und M.*, 1902 and 1906.
(22) *Mitt. A.-und G.*, 1906.
(23) *ibid.*,
(24) *M.W.*, 1904.

APPENDIX I.

BIBLIOGRAPHY OF THE RUSSO-JAPANESE WAR, 1904–05.

(*a*). THE CAMPAIGN IN GENERAL.

1. Löffler: *Der russisch-japanische Krieg in seinen taktischen und strategischen Lehren.*
2. Aubert: *Der russisch-japanische Krieg.*
3. Immanuel: *Der russisch-japanische Krieg in militärischer und politischer Beziehung.*
4. Erdmann v. Kalinowski: *Der Krieg zwischen Russland und Japan.*
5. *Der russisch-japanische Krieg:* Beiheft zum *Mar. Rund.*
6. *Der russisch-japanische Krieg, 1904,* von Giannitrapani. (B.I.K.)

(*b*). PARTICULAR OPERATIONS: EXPERIENCES AND DEDUCTIONS.

1. *Die Schlacht bei Mukden:* Beihefte z. *M. W.*, 1905.
2. Die Schlacht am Schaho: Beihefte z. *M. W.*, 1906.
3. Bronsart v. Schellendorf: *Sechs Monate beim japanischen Feldheere.*
4. "Betrachtungen über den russisch-japanischen Krieg": *Vierteljahreshefte für Truppenführung und Heereskunde*, No. 2, 1905.
5. *Erfahrungen des russisch-japanischen Krieges:* Beiheft 73 z. *Internat. Rev.*, April, 1906.
6. Immanuel: *Erfahrungen und Lehren des russisch-japanischen Krieges, 1904–05, für Heer- und Truppenführung.*
7. "Über das Versagen der europäischen Theorie im russisch-japanischen Kriege": *M. W.*, No. 136, 1904.
8. v. Janson: *Das Zusammenwirken von Heer und Flotte im russisch-japanischen Kriege.*
9. v. Normann: *Betrachtungen über den russisch-japanischen Krieg.*
10. "Die Bedeutung des Feldmörsers im gegenwärtigen Kriege": *M. W.*, No. 40, 1905.
11. "Schwere Artillerie des Feldheeres auf dem östasiatischen Kriegsschauplatze": *M. W.*, No. 45, 1905.
12. Adler: "Die russische Belagerungsartillerie": *Mitt. A.-und G.*, No. 3, 1905.

(*c*). PORT ARTHUR.

1. *Kriegsgeschichtliche Einzelschriften* d. Gr. Generalstabes. Heft 37—38: "Port Arthur."
2. "Ein Beitrag zur Beurteilung des Kampfes um Port Arthur": *Mitt. des I.-K.*, No. 40.
3. Schröter: *Port Arthur.*
4. Bulgakow: *Port Arthur.* (B.I.K.)
5. Kuchinka: "Der Kampf um Port Arthur": *Mitt. A.-und G.*, No. 3, 1905.
6. Nord: "Die Belagerung von Port Arthur": *Östasiatischer Lloyd*, 1905–06. (B.I.K.)
7. "Über die Belagerung von Port Arthur": *K.Z.*, No. 8, 1905.

8. Malczewski v. Tarnawa: "Beiträge zum Studium des Kampfes um Port Arthur": *Mitt. A.-und G.*, No. 12, 1905, and 4, 1906.
9. "Notes sur la défense de Port Arthur": *Revue du G.M.*, May, 1905.
10. Frobenius: "Der Festungskrieg im Lichte der Kämpfe um Port Arthur": *M.W.*, No. 124 und 125, 1904.
11. "Was lehrt Port Arthur?": *N.M.B.*, No. 3, 1905.
12. Stavenhagen: "Über Festungen and ihre Verteidigung, mit Bezugnahme auf Port Arthur": *Schweiz. Zeit. für A. und G.*, No. 5, 1905.
13. "Port Arthur und die Frage der Kernbefestigung": *N.M.B.*, No. 21, 1905.
14. "Bedeutung Port Arthurs": *K.Z.*, No. 7, 1905.
15. v. Schwarz: "Aus dem Tagebuche eines Ingenieurs": *Russ. Ing. J.*, No. 9—12, 1905.
16. Podgurski: "Aus den Erinnerungen über die Belagerung von Port Arthur": *Voënnyi Sbórnik*, No. 4 u. 5, 1906.

(*d*). TECHNICAL DETAILS.

1. Malczewski v. Tarnawa: *Die Schlachtfeldbefestigung nach den Erfahrungen des russisch-japanischen Krieges.*
2. "Spatenarbeit der Infanterie": *Streffleur*, Oct. and Nov., 1905.
3. Karaulschtschikow: "Der russisch-japanische Krieg und die technische Durchbildung der Armee": *Russ. Ing. J.*, No. 1 and 2, 1906.
4. Karaulschtschikow: "Der russisch-japanische Krieg und die Ingenieurtruppen": *Russ. Ing. J.*, No. 4, 1906.
5. Poljanski: "Über das Feldpionierwesen im russisch-japanischen Kriege": *Russ. Ing. J.*, No. 3, 1906.
6. v. Schwarz: "Die Befestigung der Kintschoustellung, Angriff und Verteidigung von Kintschou": *Russ. Ing. J.*, No. 1—3, 1906.
7. Sacharow: "Über die Arbeiten in der befestigten Stellung des 6. Sib. Armeekorps am Schaho": *Russ. Ing. J.*, No. 4, 1906.
8. Tschernik: "Persönliche Eindrücke eines Teilnehmers des russisch-japanischen Krieges betr. einige Fragen des Feldpionierwesens (Stellung der 3. Mandschureiarmee am Schaho)": *Russ. Ing. J.*, No. 5, 1906.
9. Toepfer: "Die Technik im russisch-japanischen Kriege": *K.Z.*, No. 2—4, 1906.
10. Sacharow: "Wege- und Brückenbauten während des Krieges in der Mandschurei": *Russ. Ing. J.*, No. 7 and 8, 1905.
11. Sokolow: "Die Wege der Mandschurei und ihre Ausbesserung während des russisch-japanischen Krieges": *Russ. Ing. J.*, No. 1 and 2, 1906.
12. Kisseljew: "Die Pontoniere im fernen Osten": *Russ. Ing. J.*, No. 2, 1905, 7 and 8, 1905, 9 and 10, 1905.
13. Sacharow: "Zerstörung von Übergängen beim Rückzuge der Russen von Liaoyan": *Russ. Ing. J.*, No. 5 and 6, 1905, 4, 1906.
14. Kowarik: "Der Nachrichtendienst im russisch-japanischen Kriege": *Schweiz. Zeit. für A. und G.*, No. 8, 1905, 4, 1906.
15. Das Ing.-Kom. bearbeitet *Pionierwesen im russisch-japanischen Kriege*, 1904–05.

APPENDIX II.

THE ORGANIZATION AND MILITARY DUTIES OF ENGINEERS AND PIONEERS.

A. GENERAL REMARKS.

Interesting discussions have recently taken place, especially in Germany and England, on the development and organisation of engineers, pioneers, and troops of the train. We will here confine ourselves to their present organisation. It is known that most Countries have not yet effected a separation between the engineers and pioneers and the train.

B. THE VARIOUS STATES.

The works mentioned in Part I. C. (*a*) deal in a general way with questions of organisation, and also draw attention to eventual alterations. The following publications may be mentioned in addition:—

Z. B. Wagner: "Grundzüge der Reorganisation des Ingenieurkorps und der Pioniere": *Jahrb. für A. und M.*, March, 1900.

Frobenius: *Gedanken über Organisation und Neu-organisation des Ingenieurkorps.* Berlin, 1892.

"Die Umformung der technischen Waffe": *Jahrb. für A. und M.*, March, 1894.

Schwenninger: *Zur Neugestaltung des Ingenieur- und Pionierkorps*, Berlin, 1901, and *Unsere Pioniere*, Berlin, 1904.

Hartmann: "Mehr Pioniere": *K.Z.*, 1904.

"Zur Frage der Organisation des Ingenieurkorps": *N.M.B.*, 1905.

"Die Verwendung und Ausbildung der Pioniere" and "Kriegsaufgabe und Kriegswert der Pioniere": *K.Z.*, 1905.

"Die Ausbildung der Pioniertruppe": *Vierteljahrshefte für Truppenführung und Heereskunde*, 1906, and *R.E.J.*, 1905–06.

Mitt. des I.-K., No. 39. 1905.

Balck: *Zusammenstellung der wichtigstein Angaben über die taktische Verwendung, Ausrüstung, Bewaffnung* (etc.) *der deutschen, österreichischen* (etc.) *Armee.* Berlin, 1901.

"Das Ingenieurkorps in Deutschland, Frankreich, und Österreich: seine Organisation und Ergänzung": *Russ. Ing. J.*, 1904.

Stavenhagen: *Verkehrs-, Beobachtungs- und Nachrichtenmittel in militärischer Beleuchtung.* Gottingen und Leipzig, 1905.

Corticelli: *Manuale di organica militare Eserciti Italiano, Germanico, Austro-Ungarico, Francese, Russo, e Swizzero.* Turin, 1901.

(*a*). GERMANY.

Reference may be made to the *Regulations*; to the Prussian, Bavarian, and Saxon *Army Lists*; to the pamphlets,* dealing with army matters, used in the military schools; and to "The Engineers of the German Army": *R.E.J.*, 1906.

(*b*). BULGARIA.

"Das bulgarische Heerwesen": *Internat. Rev.*, 1906, Beiheft 66.

"Bulgarien. Artillerie und technische Truppen. Bewaffnung und technische Ausrüstung der Armee": *Mitt. A.-und G.*, 1905.

(*c*). ENGLAND.

The "Notes on Royal Engineer Duties in the German Army"† give a comparison between the English and German organisations. We may also mention:—

"Organisation des Geniekorps in England": *Mitt. A.-und G.*, 1897.

"The Administration and Organisation of the Army in India": *Jour R.U.S.I.*, 1904.

"Die neue Gliederung des Heeres und zugleich neue militärische Landeseinteilung in England": *M.W.*, 1905.

"Organisation of Royal Engineers for War": *R.E.J.*, 1905.

"Die Entwickelung des englischen Heerwesens nach der Beendigung des Burenkrieges": *Vierteljährshefte für Truppenführung und Heereskunde*, 1905.

Balck: "Das englishe Landheer": *England in deutscher Beleuchtung*, Heft 4. (B.I.K.).

Mitt. des I.-K., No. 37, 1904.

(*d*). FRANCE.

Reference may be made to:—

"Beitrage zum Festungskrieg": *Schweiz. Zeit. für A. und G.*, 1905.

Aide-Mémoire de l'Officier d'Etat-major en Campagne. Paris, 1902.

A few of the points in question are also alluded to in:—

Roche: *Le Service des troupes du Génie aux Armées.* Paris, 1894. (B.I.K.)

(*e*). GREECE.

"Griechenland. Artillerie und Genie.," *Mitt. A.-und G.*, 1905.

(*f*). ITALY.

"Italien. Artillerie und technische Truppen. Bewaffnung und Ausrüstung der italienischen Armee": *Mitt. A.-und G.*, 1905.

"Die italienische Wehrmacht": *Streffleur*, 1905.

"Die italienische Artillerie, Kavallerie, und Genietruppe": *Streffleur*, 1905.

* *Leitfaden für den Unterricht über Heerwesen an den königlichen Kriegschulen.* Berlin, 1902.

† *Professional Papers of the Corps of R.E.*, 1900.

(*g*). NETHERLANDS.

"Die Niederländische Armee und ihre Kriegsgliederung": *Jahrb. für A. und M.*, 1905.

(*h*). AUSTRIA-HUNGARY.

"Neuerungen bei den technischen Truppen": *N.M.B.*, 1905.

(*j*). PORTUGAL.

"Aperçu de l'Armée Portugaise en 1905": *Rev. Mil. des A.E.*, 1905.

(*k*). RUSSIA.

von Carlowitz-Maxen: "Einteilung und Dislokation der russischen Armee." Published half-yearly.

"Das Ingenieurkorps; seine Aufgabe, Organisation und Dienst im Krieg und Frieden": *Russ. Ing. J.*, 1902.

von Tettau: *Ergänzung und Organisation der russischen Armee im Kriege und Frieden.* Berlin, 1902.

(*l*). ROUMANIA.

"Die rumänische Armee": *Streffleur*, 1904.

"Rumanien. Gliederung der Artillerie und der technischen Truppen": *Mitt. A.-und G.*, 1905 and 1906.

(*m*). SWEDEN, NORWAY, AND DENMARK.

von Löbell's *Jahresberichte über die Veränderungen und Fortschritte im Militärwesen*, 1905.

(*n*). SWITZERLAND.

"Beitrage zum Festungskrieg": *Schweiz. Zeit. für A. und G.*, 1905.

Weber: *Armee und Geniewaffe.* Berne, 1902.

(*o*). SPAIN.

"Vom spanischen Heere": *M.W.*, 1904.

"Die Neuorganisation der spanischen Armee": *Internat. Rev.*, 1905, Supplt. 64, and *Streffleur*, 1905.

"The Engineers of the Spanish Army": *R.E.J.*, 1905.

(*p*). TURKEY.

"Turkei. Technische Truppen. Befestigungswesen": *Mitt. A.-und G.*, 1902.

(*q*). CHINA.

"Das chinesische Heerwesen": *Internat. Rev.*, 1905, Suppt. 62.

"Die Streitkräfte Chinas": *Streffleur*, 1904.

(*r*). JAPAN.

"Streitkräfte Japans": *Streffleur*, 1904.

"Die Ingenieurtruppen des japanischen Heeres": *Russ. Ing. J.*, 1905.

"Technische Truppen und technische Ausrüstung": *Mitt. A.-und G.*, 1905.

(*s*). KOREA.

"Koreas Heer und Marine": *Internat. Rev.*, 1903.

(*t*). UNITED STATES OF AMERICA.

"Die Wehrmacht der Vereinigten Staaten von Nordamerika": *Streffleur*, 1901.

Vincent: "The United States Army": *Jour. R.U.S.I.*, 1905.

"Militärschulen für die Artillerie und technischen Truppen": *Mitt. A.-und G.*, 1906.

"Vereinigten Staaten von Nordamerika. Artillerie und technische Truppen": *Mitt. A.-und G.*, 1905.

(*u*). MEXICO.

"Die mexikanische Armee": *Schweiz. mil. Zeit*, 1903.

(*v*). ARGENTINA.

"Vom argentinischen Heere": *M.W.*, 1905.

(*w*). MOROCCO.

"Das Heerwesen Marokkos": von Löbell's *Jahresberichte*, 1902.